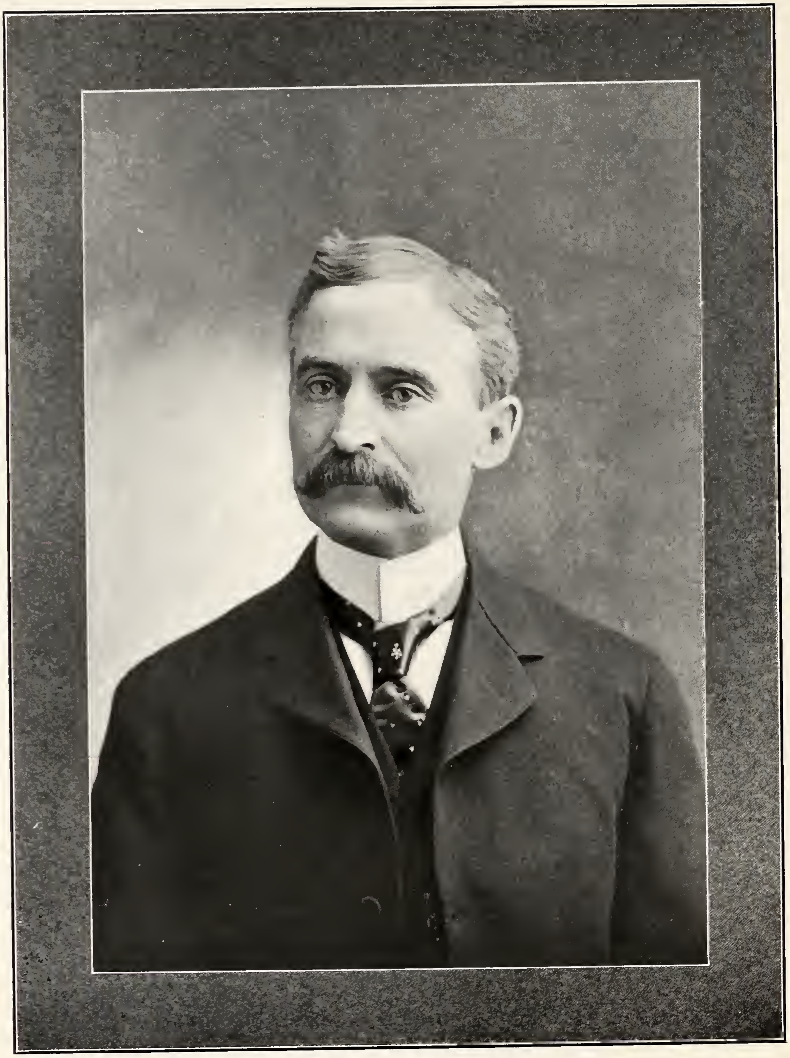


Geo. W. Tillson

BROOKLYN ENGINEERS' CLUB.

ORGANIZED OCT. 9, 1896.
INCORPORATED DEC. 29, 1896.

PROCEEDINGS FOR 1900

CONSTITUTION AND BY-LAWS

AND

CATALOGUE OF REFERENCE WORKS IN THE LIBRARY.

PRICE, TWO DOLLARS.

Published by the BROOKLYN ENGINEERS' CLUB.
Office of Secretary, 191 Montague Street, and Library of Club in the Brooklyn Library Building, Montague Street, near Fulton, Brooklyn, New York.

JANUARY, 1901.

BROOKLYN ENGINEERS' CLUB.

CONTENTS.

BROOKLYN ENGINEERS' CLUB.

CONSTITUTION AND BY-LAWS.

ARTICLE I.

NAME, LOCATION AND OBJECT.

SECTION 1. The name of this Association shall be the

"BROOKLYN ENGINEERS' CLUB."

SEC. 2. The offices of the Club shall be located in the City of Brooklyn.

SEC. 3. The object of the Club shall be to promote social and professional intercourse among its members; to advance engineering knowledge and practice, and to maintain a high standard of professional procedure in all respects.

SEC. 4. The means to be employed for this purpose shall be: Meetings for the presentation and discussion of appropriate papers and for social and professional intercourse; the publication of such papers and discussions as may be deemed expedient; the maintenance of a technical library, and such other means as may be deemed proper.

ARTICLE II.

MEMBERSHIP.

SECTION 1. The Club shall consist of Corporate, Associate, Non-Resident and Honorary members.

SEC. 2. A Corporate member shall be a civil, military, naval, mechanical, electrical, mining or other engineer, architect, surveyor or analytical chemist, or a person who has taken a course in a technical school with the purpose of entering one of the above-mentioned professions. He shall be either a resident of Brooklyn, or one of the other Boroughs of the City of New York, or a practitioner therein, at the time of his election.

SEC. 3. An Associate member shall be a person residing, or doing business in Brooklyn, or another Borough of the City of New York, at the time of making his application, who has such a knowledge of or

connection with applied science as qualifies him, in the opinion of the Board of Directors, to co-operate with engineers in the advancement of professional knowledge.

Sec. 4. A Non-Resident member shall be one possessing the qualifications enumerated in Sections 2 and 3, whose residence and place of business are both outside of the City of New York.

Sec. 5. A Corporate or Associate member who shall remove his residence and place of business to the distance stated in Section 4, may be transferred to the Non-Resident class at the beginning of the fiscal year following such removal, provided notice of the removal be filed with the Secretary at the time of payment of the annual dues, or not later than February 1st.

Sec. 6. A Non-Resident member who shall remove his residence or place of business to within the City of New York, shall become a full member in the same manner as specified in Article III, but shall not be required to pay an entrance fee. Provided, however, that his application for full membership shall be filed within three (3) months of his removal, otherwise his name shall be dropped from the roll of the Club by the Board of Directors at the beginning of the next calendar year, except that no action shall be taken unless a copy of this section shall have been served upon him at least four (4) weeks prior to such action.

Sec. 7. Honorary members shall be chosen from persons resident in Brooklyn, of acknowledged eminence in the pursuit of their profession, or on account of their contributions to the welfare of the community along professional or municipal lines. There shall not be more than five (5) Honorary members at any one time.

Sec. 8. Associate, Non-Resident, and Honorary members shall not be entitled to vote or hold office, but shall enjoy all other Club privileges, except that Non-Resident members will not be entitled to the library privileges.

ARTICLE III.

ADMISSIONS AND EXPULSIONS.

Section 1. An application for admission to the Club as a Corporate member or for transfer from the Non-Corporate to the Corporate grade, shall embody a concise statement, with dates, of the candidate's professional training and experience, and shall be in a form and in such detail as may be prescribed by the Board of Directors. It shall be signed by the applicant, and shall contain a promise to conform to the requirements of membership if elected. The applicant shall give at least three (3) references, two of whom shall be Corporate members in good standing.

SEC. 2. The above application shall be made through the Secretary, who shall post the name of the applicant on the bulletin board of the Club, and transmit the application to the President.

The qualifications of the applicant for membership shall be referred to the Committee on Membership, or, if the President deem it advisable, to a special committee of three (3) members to be appointed by him. It shall be the duty of this Committee to thoroughly investigate the personal and professional fitness of the candidate, and to report in writing the result of said investigation to the Board of Directors as soon as practicable thereafter.

When this report shall have been made to the Board of Directors, the said Board shall present the application, if approved by them, at the next regular meeting of the Club, or as soon thereafter as possible, or withhold it at their discretion, except that upon a written request of five (5) Corporate members to the Board of Directors, said Board shall submit said application at the next regular meeting of the Club, together with the report as to why said application had been withheld.

SEC. 3. An application which shall have had the approval of the Board of Directors shall be balloted upon at a regular meeting by the members present, provided a notice to that effect shall have been given by the Secretary to the members of the Club. A four-fifths ($\frac{4}{5}$) vote of those voting shall be necessary for election.

SEC. 4. The application of any candidate, once rejected, shall not be considered by the Board of Directors, within one year, unless the same be accompanied by a request signed by not less than five (5) Corporate members asking for a reconsideration of the ballot, and stating the reason for such request. The Board of Directors, should it deem those reasons sufficient, shall present said application at the next regular meeting of the Club, with the request that it be acted upon.

SEC. 5. All elected candidates shall be duly notified and shall subscribe to the Constitution and Rules of the Club.

If these provisions are not complied with within thirty (30) days from the notification of election, such election shall be considered void unless, for special reason, the time shall be extended by the Board of Directors. Membership of any person shall date from the day of his election.

SEC. 6. Honorary members shall be proposed by the Secretary upon the unanimous recommendation of the Board of Directors at a regular meeting, and be balloted upon at the next regular meeting. Four-fifths ($\frac{4}{5}$) of the votes cast shall be necessary for an election.

A person elected an Honorary member shall be promptly notified thereof by letter; the election shall be canceled if an acceptance is not received within ninety (90) days after mailing such notice.

SEC. 7. Upon the written request of six or more Corporate members, that for cause therein set forth a person belonging to the Club be expelled, the Board of Directors shall consider the matter, and, if there appear to be sufficient reason, shall advise the accused of the charges against him. He may, if he so desire, present a written defense, which shall be considered at a meeting of the Board of Directors, of which he shall receive due notice and at which he may appear with counsel. Unless the defense made be satisfactory to the Board of Directors, they shall, after two months have elapsed, unless his resignation has already been tendered, notify the person that he must present the same within thirty (30) days, or he will then be expelled.

An appeal may be taken against such a course, in which case a special meeting will be called for the purpose of submitting to the Club all the evidence in the case. A majority of the votes cast at this special meeting will be required to sustain the action of the Board. The Secretary will notify all Corporate members of the Club of the result of the ballot. In case no appeal be made, the Board of Directors will expel the person and notify him and the Corporate members of its action.

SEC. 8. A member of any grade in the Club may resign his membership by a written communication to the Secretary, who will present the same to the Board of Directors; when, if his dues have been paid, his resignation will be accepted.

ARTICLE IV.

ENTRANCE FEES AND DUES.

SECTION 1. The dues on admission to the Club and yearly thereafter shall be:

For Corporate member, Eight (8) Dollars.
For Associate member, Six (6) Dollars.
For Non-Resident member, Three (3) Dollars.

SEC. 2. Corporate, Associate and Non-Resident members shall pay an entrance fee of Five Dollars upon admission to the Club.

The annual dues shall be payable for the ensuing year on the first day of January.

It shall be the duty of the Secretary to notify each member of the amount due for the ensuing year at the time of giving notice of the annual meeting.

SEC. 3. A person elected after six months of any fiscal year shall have expired shall pay only one-half of the amount of dues for that fiscal year.

SEC. 4. Any person whose dues are more than one month in arrears shall be notified by the Secretary. Should his dues not be paid when they become three months in arrears, he shall lose all Library

privileges secured through the membership in the Club, and lose his right to vote. Should his dues become four months in arrears he shall again be notified in form prescribed by the Board of Directors, and should such dues become six months in arrears he shall forfeit his connection with the Club. The Board of Directors may, for cause deemed by them sufficient, extend the time for payment and for application of these penalties.

Sec. 5. The Board of Directors may, for sufficient cause, reduce the annual dues of any member to three (3) dollars, and of any Associate member to one (1) dollar, provided all Library privileges are waived by the person making application therefor, which must be in writing.

Sec. 6. Every member admitted to the Club shall be considered as belonging thereto, and liable for payment of dues until he shall have resigned or been expelled therefrom.

ARTICLE V.

OFFICERS.

Section 1. The officers of the Club shall be a President, Vice-President, Secretary and Treasurer, who with the retiring President shall constitute a Board of Directors in which the government of the Club shall be vested, and who shall be the Directors as provided for by the laws under which the Club is incorporated; and also a Librarian.

Sec. 2. The President shall be ineligible for election to two successive terms of office.

Sec. 3. The term of office for all officers shall be one (1) year, except for the Vice-President, who shall hold office for two (2) years.

Sec. 4. A vacancy in the office of President shall be filled by the Vice-President.

Sec. 5. At the first annual meeting there shall be elected a Trustee, who shall act as a member of the Board of Directors and shall serve for one year. Any vacancy occurring in the Board by resignation, death or otherwise, shall be filled for the unexpired term by its remaining members.

Sec. 6. All officers shall be elected by ballot, except the Librarian, who shall be elected by the Board of Directors, at their meeting immediately preceding the January meeting of the Club.

ARTICLE VI.

MANAGEMENT.

Section 1. The President, acting under the direction of the Board of Directors, shall exercise a general supervision over the affairs of the Club. He shall preside at all business meetings of the Club and Board

of Directors at which he may be present, call special meetings when the same may be necessary, and appoint such committees as are herein provided for. He shall act as *ex-officio* member of all committees which he shall appoint.

Sec. 2. The Vice-President shall preside at business meetings in the absence of the President.

Sec. 3. The Board of Directors shall manage the affairs of the Club in conformity to the laws under which the Club is incorporated, and the provisions of this Constitution. They shall direct the investment and care of the funds of the Club; make appropriations for specific purposes; act upon applications for membership, as heretofore provided; constitute the Auditing Board, and generally conduct the business of the Club. The Board of Directors shall make an annual report at the annual meeting, transmitting the report of the Treasurer and of other officers and committees.

Sec. 4. The Secretary, under the direction of the President and the Board of Directors, shall be the executive officer of the Club. He shall keep a record of all business meetings. He shall notify the members of all meetings and postponements thereof, and of all other matters as directed by the President and the Board of Directors. It shall also be his duty to take charge of and preserve all papers read and discussed, and, when directed by the Board of Directors, prepare copies or abstracts of the same for publication.

He shall see that all moneys due the Club are collected and transferred to the Treasurer. He shall verify the correctness of all bills presented for payment and charge same to the proper appropriations. He shall have charge of the books of account of the Club, and shall furnish to the Board of Directors a statement of receipts and expenditures under their several headings annually and at such other times as the Board may direct. He shall conduct the correspondence of the Club and keep full record of the same. He shall perform such other duties as may from time to time be assigned to him by the Board of Directors.

Sec. 5. The Treasurer shall be the custodian of the funds of the Club. He shall receive all moneys collected by the Secretary, and deposit the same to the credit of the Club in such depository as may be directed by the Board of Directors. He shall pay all bills, duly approved, by check, countersigned by the President, and shall keep book accounts of his receipts and expenditures, which shall be at all times open to inspection by the Board of Directors. He shall present a monthly report to the Board showing the receipts and expenditures during the previous month and the balance in his hands at the time of making such report. He shall make an annual report to be audited and presented to the Club by the Board of Directors.

Sec. 6. The Librarian shall be the Executive Officer of the Library Committee, of which he shall be an *ex-officio* member. He shall have direct charge of all books, periodicals, transactions, and other publications contained in the Library, subject to the direction of the Library Committee.

Sec. 7. The President, within ten days after the annual meeting, shall appoint a Library Committee of three, a Committee on New Membership of three, and an Entertainment Committee of three, members of the Club, which committee shall be subject to the direction of the Board of Directors.

Sec. 8. The Library Committee shall have general charge of the Library and shall take the necessary steps to procure all books, periodicals, transactions, reports, publications, etc., etc., that may be needed; present prior to the annual meeting a report to the Board of Directors, showing the increase in the Library during the year, and a statement of the moneys expended; also present an estimate of the money needed for Library purposes for the coming year.

Sec. 9. The Committee on New Membership shall investigate the fitness of all candidates for membership that may be referred to them by the President, see that the objects and advantages of the Club are at all times kept before the community in a proper spirit, and, generally, see that the Club preserves a healthy and desirable growth.

Sec. 10. The Entertainment Committee shall have charge of arranging the social features of all meetings, and shall provide suitable papers to be presented before the Club. It shall be their duty to transmit all necessary information concerning the same to the Secretary in time for inserting notices in the notification of meetings.

Sec. 11. The Secretary and the Librarian shall receive such compensation for their services as the Board of Directors may determine; but such compensation, when fixed, shall not be reduced during the term of office, as provided in this Constitution. All other salaries shall be fixed from time to time, by the Board of Directors.

ARTICLE VII.

MEETINGS.

Section 1. There shall be eight (8) regular meetings of the Club per annum, to be held on the second Thursday in each month, except during the months of June, July, August and September.

Sec. 2. The annual meeting, at which the officers for the ensuing year shall be elected and all annual reports read, shall be held on the second Thursday in December in each year.

Sec. 3. Whenever the President shall deem it necessary, or upon the written application of five (5) Corporate members, he shall direct the Secretary to call a special meeting. The notice thereof shall state the time and place of holding the meeting and the purpose for which it is called, and shall be mailed not less than five days previous to the date of the proposed meeting.

Sec. 4. At all regular and special meetings of the Club, ten (10) Corporate members shall constitute a quorum.

Sec. 5. The Club may adopt, from time to time, rules for the order of business at its meetings.

Sec. 6. At the regular or special meeting of October, 1897, and annually thereafter, a committee of five (5) Corporate members shall be elected by the members present to make nominations for officers to be balloted for at the ensuing annual election. Said Committee shall report their list of nominations at the regular meeting in November, and the list shall be sent to each Corporate member by the Secretary, in the regular notification of the annual meeting. And it shall be the duty of the Secretary to send with such nominations any other nominations, on the written request of five (5) Corporate members filed with him ten (10) days before the date of the annual meeting. The said notices shall be mailed by the Secretary one week before the annual election.

In the event of failure to elect a Nominating Committee at an October meeting, it shall be the duty of the Board of Directors to appoint such committee.

ARTICLE VIII.

AMENDMENTS.

Section 1. Proposed amendments to this Constitution must be reduced to writing and signed by not less than five (5) Corporate members, and be submitted and acted upon as follows:

Sec. 2. The amendment, as proposed, shall be sent by letter to the several Corporate members, with the statement that the matter will come up before the next regular meeting for discussion unless otherwise ordered.

Sec. 3. At the discussion the proposed amendment may be amended in any way by a majority of those present and voting.

Sec. 4. The amendment, as amended, shall then be sent by letter to the several Corporate members, wherein the meeting for final action therein will be announced. When final action is taken, a two-thirds ($\frac{2}{3}$) vote in favor of said amendment, as amended, will be necessary for its adoption.

FIRST OFFICERS AND CHARTER MEMBERS, 1896.

Temporary President, ANDREW J. PROVOST, JR.

Temporary Secretary, WILLIAM G. FORD.

Temporary Treasurer, GEORGE W. TILLSON.

Committee on Constitution and By-Laws and Committee on Library:

A. J. CALDWELL, GEORGE W. TILLSON, WALTER M. MESEROLE, A. J. PROVOST, JR. WILLIAM G. FORD.

Committee on Incorporation:

A. J. PROVOST, JR., WILLIAM G. FORD.

CHARTER MEMBERS.

O. F. Balston,
Fred. L. Bartlett,
Homer L. Bartlett,
Herbert J. Barker,
W. L. Beers,
R. T. Betts,
William E. Belknap,
Francis Blossom,
J. C. Brackenridge,
David Brower,
William T. Bruorton,
Edmund J. Burke,
Andrew J. Caldwell,
D. Frederick Carver,
Frank J. Conlon,
Albert S. Crane,
Frederick A. Drake,
John H. Dwyer,
William G. Ford,
Edwin J. Fort,
Arthur J. Griffin,
Thomas S. Griffin,
Walter R. Griffith,
George T. Hammond,
Arthur S. Ives,
Carl A. Johnsen,
Jacob Stinman Langthorn,
J. Calvin Locke,
Edward L. Maltby,
James C. Meem,
Walter M. Meserole,
Peter Milne,
Frank O. Nowaczek,
Arthur I. Perry,
Frederick E. Pierce,
Clarence D. Pollock,
Andrew J. Provost, Jr.,
*G. S. Roberts,
George F. Rowell,
Joseph Strachan,
Edwin C. Swezey,
George W. Tillson,
Kenneth Torrance,
Arthur S. Tuttle,
William D. Vanderbilt,
*John H. Van der Veer,
Bernard M. Wagner,
E. Sherman White,
Richard L. Williams,
George E. Winslow.

* Deceased.

OFFICERS, 1900.

President: George W. Tillson.
Vice-President: Henry B. Seaman.
Secretary: Andrew J. Provost, Jr.
Treasurer: Calvin W. Rice.

BOARD OF DIRECTORS.

George W. Tillson, Henry B. Seaman,
Andrew J. Provost, Jr., Calvin W. Rice,
Walter M. Meserole.

STANDING COMMITTEES.

Entertainment: W. S. Tuttle, W. V. Cranford, H. S. Demarest.
Membership: W. T. Bruorton, F. G. Cudworth, E. C. Shaler.
Library: Joseph Strachan, J. C. Locke, A. J. Provost, Jr.

SPECIAL COMMITTEES.

Excursions: W. G. Ford, J. C. Meem, R. N. Wheeler.
Publication: J. W. Roe, G. F. Rowell, C. D. Pollock, F. J. Conlon, W. M. Meserole.

OFFICERS, 1901.

President: Joseph Strachan.
Vice-President: Willard S. Tuttle.
Secretary: Andrew J. Provost, Jr.
Treasurer: George C. Whipple.

BOARD OF DIRECTORS.

Joseph Strachan, Willard S. Tuttle,
Andrew J. Provost, Jr., George C. Whipple,
George W. Tillson.

STANDING COMMITTEES.

Entertainment: Frank G. Cudworth, D. D. Jackson, C. E. Trout.
Membership: F. W. Carpenter, R. R. Crowell, H. S. Wynkoop.
Library: F. S. Woodward, J. W. Roe, R. D. Chase.

SPECIAL COMMITTEES.

Excursions: C. D. Pollock, F. W. Conn, J. S. Langthorn, W. E. Roach, E. Conway Shaler.
Publication: Kenneth Torrance, F. S. Woodward, H. K. Landis, F. A. Drake, John Middleton.

LIST OF MEMBERS.

ORGANIZED OCTOBER 9TH, 1896.

HONORARY MEMBER.

Name.	Address.	Date of Election.
WHITE, ALFRED T.	40 Remsen St., Brooklyn, New York City	May 12, 1898

CORPORATE MEMBERS.

Name.	Address.	Date of Election.
BALSTON, OSCAR F.	Civil Engineer, 103 Decatur St., Brooklyn, New York City	Nov. 6, 1896
BARKER, HERBERT J.	Dept. of Highways, Brooklyn, New York City	Nov. 6, 1896
BARSTOW, WILLIAM S.	General Superintendent, Edison Electric Illuminating Co., 360 Pearl St., Brooklyn, New York City	Jan. 10, 1901
BARTLETT, FRANK R.	Assistant Engineer, Dept. of Sewers, Brooklyn, New York City	Jan. 7, 1897
BARTLETT, FRED. L.	Civil Engineer and City Surveyor, 191 Montague St., Brooklyn, New York City	Nov. 6, 1896
BARTLETT, HOMER L.	Civil Engineer and City Surveyor, 191 Montague St., Brooklyn, New York City	Nov. 6, 1896
BEACH, ROBERT J.	Civil Engineer, 191 Montague St., Brooklyn, and 149 Broadway, Manhattan, New York City	Feb. 4, 1897
BEERS, W. L.	Contracting Civil Engineer, 258 Prospect Pl., Brooklyn, New York City	Nov. 6, 1896
BERGER, BERNT	Civil Engineer, 35 Broadway, Manhattan, New York City	April 1, 1897
BETTS, R. T.	Assistant Engineer, Dept. of Docks, Foot of East 39th St., Manhattan, New York City	Nov. 6, 1896
BLOSSOM, FRANCIS	Sanderson and Porter, 31 Nassau St., Manhattan, New York City	Nov. 6, 1896

Name.	Address.	Date of Election.
Boyrer, William C	Engineer Installation and Maintenance N. Y. and N. J. Tel. Co., 81 Willoughby St., Brooklyn, New York City	Jan. 10, 1901
Brackenridge, J. C	General Manager, Brooklyn Heights R. R. Co., 168 Montague St., Brooklyn, New York City.	Nov. 6, 1896
Braine, Bancroft G	Mechanical Engineer, 67 First Pl., Brooklyn, New York City	April 1, 1897
Braine, Lawrence F	General Manager, Continuous Rail Joint Co., 912 Prudential Building, Newark, N. J	Jan. 12, 1899
Broadhurst, Wm. H	Chemist, Dept. of Highways, 13–21 Park Row, Manhattan, New York City	March 4, 1897
Brower, David	Assistant Engineer, Dept. of Sewers, Brooklyn, New York City	Nov. 6, 1896
*Brown, Robert P	Electrical Engineer, Brooklyn Heights R. R. Co., 168 Montague St., Brooklyn, New York City.	May 6, 1897
Bruorton, William T	Assistant Engineer, Dept. of Sewers, Brooklyn, New York City	Oct. 9, 1896
Burke, Edmund J	Assistant Superintendent, Motor Dept. Brooklyn Heights R. R. Co., 168 Montague St., Brooklyn, New York City	Oct. 9, 1896
Butler, Noble C., Jr	Mechanical Engineer, Worthington Hydraulic Works, P. O. Box 14, Brooklyn, New York City	Jan. 11, 1900
Caldwell, Andrew J	Crane Co., Chicago, Ill	Oct. 9, 1896
Carpenter, Frederick W	Assistant Engineer, N. Y. Rapid Transit R. R. Com., 231 West 125th St., Manhattan, New York City	Oct. 12, 1899
Carver, D. Frederick	Chief Engineer, Cleveland Electric Railway Co., "The Wyandot," Cleveland, Ohio	Nov. 6, 1896
Chase, Richard Davenport	15 Monroe Pl., Brooklyn, New York City. With Allen Hazen, Consulting Engineer, 220 Broadway, New York City	Jan. 7, 1897

* Died February 8, 1901.

Name.	Address.	Date of Election.
Clift, Charles W.	Chief Engineer, Mount Prospect Pumping Station, 353 Park Pl., Brooklyn, New York City	May 6, 1897
Colby, Safford K.	Pittsburgh Reduction Co., 26 Cortlandt St., Manhattan, New York City	Jan. 7, 1897
Conklin, Leander H.	With George Weiderman & Co., Electrical Engineers and Contractors, 267 Flatbush Ave., Brooklyn, New York City	April 13, 1899
Conlon, Frank J.	Architect, 33 Rochester Ave., Brooklyn, New York City	Oct. 9, 1896
Conn, Charles F.	Superintendent Electrical Dept., Flatbush Gas Co., 273 Clarkson St., Brooklyn, New York City	Jan. 10, 1901
Conn, Frank W.	Superintendent New York and New Jersey Telephone Co., 81 Willoughby St., Brooklyn, New York City	April 13, 1899
Covell, Henry N.	Superintendent, Lidgerwood Mfg. Co., Brooklyn, New York City	Feb. 4, 1897
Cowperthwait, Allan	Chief Draughtsman, A. B. See Mfg. Co., 116 Front St., Brooklyn, New York City	Nov. 9, 1899
Craven, Macdonough	Sanitary Engineer, Syndicate Bldg., New York City	Jan. 7, 1897
Crowell, Robert R.	Assistant Engineer, Dept. of Bridges, Syndicate Building, Manhattan, New York City	April 14, 1898
Cudworth, Frank Grant	Assistant Engineer, Manhattan Railway Co., 195 Broadway, Manhattan, New York City	Feb. 4, 1897
Curnow, George T.	Dept. of Assessment, Brooklyn, New York City	April 1, 1897
Dodge, Richard D.	280 Henry St., Brooklyn, New York City	Feb. 8, 1900
Drake, Frederick A.	Dept. of Highways, Brooklyn, New York City	Oct. 9, 1896
Drew, John A.	Engineer and Sales Manager, Worthington Hydraulic Works, 86 Liberty St., Manhattan, New York City	Feb. 4, 1897
Drewett, William A.	Superintendent, Davidson Steam-Pump Works, Brooklyn, New York City	Feb. 4, 1897

Name.	Address.	Date of Election.
DURYEA, EDWIN, JR.	160 Cumberland St., Brooklyn, New York City	Oct. 13, 1898
DWYER, JOHN H.	Assistant Engineer, Brooklyn Heights R. R. Co., 168 Montague St., Brooklyn, New York City	Nov. 6, 1896
EATON, HENRY G.	Worthington Hydraulic Works, P. O. Box 14, Brooklyn, New York City	Oct. 11, 1900
EDWARDS, SIDNEY	Instructor, Manual Training High School, Brooklyn, New York City	May 11, 1899
EMPIE, THEODORE G.	With New York and New Jersey Telephone Co., 81 Willoughby St., Brooklyn, New York City	Jan. 10, 1901
EVANS, FRANK L.	Electrical Dept., H. W. Johns Mfg. Co., 39th St., Brooklyn, New York City	Oct. 12, 1899
FORD, WILLIAM G.	Civil and Hydrographic Engineer, 191 Montague St., Brooklyn, and 149 Broadway, Manhattan, New York City	Oct. 9, 1896
FORT, EDWIN J.	Asst. Engineer, Dept. Highways, Brooklyn, New York City	Nov. 6, 1896
FOSTER, ERNEST H.	Vice-President and Engineer, Power Specialty Co., 126 Liberty St., Manhattan, New York City	Jan. 7, 1897
FLINN, THOMAS C.	Superintendent, Kennedy Valve Mfg. Co., 57 Beekman St., New York City	Jan. 7, 1897
FRENCH, ALFRED W.	President, French Oil Mill Machinery Co., Piqua, Ohio	April 13, 1899
FULLER, GEORGE A.	110 Columbia Heights, Brooklyn, New York	Oct. 13, 1898
GERHARD, WILLIAM PAUL	Consulting Engineer for Sanitary Works, 36 Union Sq., Manhattan, New York City	June 24, 1897
GOODELL, JOHN M.	Chief Editor "The Engineering Record," 100 William St., Manhattan, New York City	Feb. 9, 1899
GOODRIDGE, JOHN W.	With Brooklyn and Jamaica Turnpike Co., 191 Montague St., Brooklyn, New York City	Oct. 11, 1900

Name.	Address.	Date of Election.
GRANGER, ABBOTT D.	Contracting Engineer, Burhorn and Granger, 95-97 Liberty St., Manhattan, New York City	Feb. 4, 1897
GRIFFIN, ARTHUR J.	45 Lefferts Place, Brooklyn, New York City	Nov. 6, 1896
GRIFFIN, THOMAS S.	Dept. of Bridges, Park Row Building, Manhattan, New York City	Nov. 6, 1896
GRIFFITH, VINCENT C.	Architect, 96 Fifth Ave., Manhattan, New York City	Jan. 7, 1897
GRIFFITH, WALTER R.	Architect, Dept. of Buildings, Lighting and Supplies, Brooklyn, New York City	Nov. 6, 1896
HAMMOND, GEORGE T.	156 Berkeley Place, Brooklyn, New York City	Oct. 9, 1896
HAMMOND, JOHN F.	Assistant Engineer, Dept. of Sewers, Brooklyn, New York City	Jan. 7, 1896
HAVILL, HAROLD H.	Engineer, 26th Ward Sewage Purification Works, No. 70 Miller Ave., Brooklyn, New York City	June 24, 1897
HAYES, HARRY EDGAR	Electrical Engineer, American Tel. and Tel. Co., 15 Dey St., Manhattan, New York City	May 6, 1897
IVES, ARTHUR STANLEY	With R. D. Wood & Co., 400 Chestnut St., Philadelphia, Pa.	Nov. 6, 1896
JACKSON, DANIEL D.	Chemist, Dept. Water Supply, Brooklyn, New York City, 177 6th Ave., Brooklyn, New York City	Oct. 13, 1898
*JACOBSEN, PETER C.	Inspector, Driven Wells, Dept. of Water Supply, Brooklyn, New York City	Nov. 4, 1897
KENNEDY, DANIEL	President and General Manager, Kennedy Valve Mfg. Co., 57 Beekman St., Manhattan, New York City	May 6, 1897
KIRBY, I. HENRY	Dept. of Sewers, Brooklyn, New York City	Oct. 12, 1899
LANDIS, HENRY K.	Associate Editor "Progressive Age," 280 Broadway, Manhattan, New York City	Jan. 12, 1899

* Died March 12, 1900.

Name.	Address.	Date of Election.
Langlotz, Charles	Chief Engineer, Lowell M. Palmer and Brooklyn Cooperage Cos., North 7th St. and Kent Ave., Brooklyn, New York City	April 1, 1897
Langthorn, Jacob S	Asst. Engineer, Dept. of Bridges, 179 Washington St., Brooklyn, New York City	Oct. 9, 1896
Lewis, Nelson P	Engineer of Highways, Dept. of Highways, Brooklyn, New York City	June 24, 1897
Locke, J. Calvin	818 Marcy Ave., Brooklyn, New York City	Nov. 6, 1896
Maltby, Edward L	Worthington Hydraulic Works, Brooklyn, New York City	Oct. 9, 1896
Martin, Charles B	Electrical Engineer, N. Y. and B. Bridge, 179 Washington St., Brooklyn, New York City	May 6, 1897
Martin, Kingsley L	Assistant Engineer, New East River Bridge, 84 Broadway, Brooklyn, New York City	Jan. 7, 1897
Meem, James Cowan	Assistant Engineer, N. Y. Rapid Transit R. R. Com., 13 Astor Pl., Manhattan, New York City	Oct. 9, 1896
Merrill, Ogden	Asst. Engineer, with Arthur McMillan & Co., Manhattan, New York City, 78 S. 10th St., Brooklyn, N. Y. City	Jan. 10, 1901
Meserole, Walter M	Civil Engineer and Surveyor, 191 Montague St., Brooklyn, New York City	Oct. 9, 1896
Milne, Peter	Civil and Hydraulic Engineer, Bennett Bld., Nassau and Fulton Sts., Manhattan, New York City	Nov. 6, 1896
Middleton, John	Civil Engineer and City Surveyor, 2789 Atlantic Ave., Brooklyn, New York City	Jan. 7, 1897
Mosscrop, William A	With Long Island Division, New York and New Jersey Telephone Co., 47 Brevoort Pl., Brooklyn, New York City	Jan. 10, 1901
Murphy, Alexander D	Assistant Engineer to Samuel H. McElroy, 26 Court St., Brooklyn, New York City	Oct. 12, 1899

Name.	Address.	Date of Election.
Myers, John H., Jr.	Assistant Engineer, N. Y. Rapid Transit R. R. Com., New York City	June 24, 1897
Nowaczek, Frank O.	Dept. of Taxes and Assessments, Brooklyn, New York City	Nov. 6, 1896
Oakes, Frank J.	Mechanical Engineer, with Henry R. Worthington, P. O. Box 14, Brooklyn, New York City	May 6, 1897
Ould, John G.	Supt. Polhemus Memorial Clinic, Henry and Amity Sts., Brooklyn, New York City	Feb. 8, 1900
Packe, Edward H.	Engineer M. W., Track Dept., Brooklyn Heights R. R. Co., 168 Montague St., Brooklyn, New York City	Jan. 7, 1897
Park, James H.	Engineer, Brooklyn Dept. Sanborn-Perris Map Co., 164 Montague St., Brooklyn, New York City	June 24, 1897
Perry, Arthur Irving	Assistant Engineer, Dept. of Highways, Brooklyn, New York City	Nov. 6, 1896
Perry, Francis W.	Dept. Highways, Municipal Building, Brooklyn, New York City	Oct. 12, 1899
Pickett, John A.	Engineer, Alcatraz Co., 421 Bee Building, Omaha, Neb	Oct. 7, 1897
Pollock, Clarence D.	Assistant Engineer, N. Y. Rapid Transit R. R. Com., 13 Astor Pl., Manhattan, New York City.	Oct. 9, 1896
Provost, Andrew J., Jr.	Assistant Engineer, Dept. of Finance, 54 Stewart Bld., Manhattan, New York City	Oct. 9, 1896
Rice, Calvin W.	Electrical Engineer, 55 Duane St., Manhattan, New York City	April 14, 1898
Roach, William E.	Assistant Engineer, Dept. Finance, 54 Stewart Building, Manhattan, New York City	Jan. 11, 1900
Roberts, Winfred H.	Assistant Engineer, Dept. Finance, 54 Stewart Building, Manhattan, New York City	April 13, 1899
Roe, Joseph W.	With J. H. Williams & Co., 9 Richards St., Brooklyn, New York City	Oct. 13, 1898

Name.	Address.	Date of Election.
Runyon, Frederick O.	Engineer, N. Y. and N. J. Telephone Co., 81 Willoughby St., Brooklyn, New York City	Jan. 10, 1901
Schermerhorn, Richard, Jr.	183 Prospect Place, Brooklyn, New York City	Jan. 12, 1899
Schmitz, Frank C.	Continuous Rail Joint Co., 912 Prudential Bld., Newark, N. J.	Jan. 11, 1900
Scollay, Ulysses G.	Manager, John A. Scollay Mfg., Heating and Ventilating Co., 74–76 Myrtle Ave., Brooklyn, New York City	April 12, 1900
Seaman, Henry B.	Consulting Engineer, 40 Wall St., Manhattan, New York City	Jan. 6, 1898
Shaler, Edgar C.	Chief Draughtsman, Brooklyn Heights R. R. Co., 168 Montague St., Brooklyn, New York City	April 14, 1898
Sheridan, John C.	Leveler, Dept. Highways, Brooklyn, New York City	Jan. 10, 1901
Sillman, William	Chief Engineer, H. W. Johns Mfg. Co., 39th St., Brooklyn, New York City	Jan. 11, 1900
Slaney, Henry C.	Brooklyn Union Gas Co., Kent and Washington Aves., Brooklyn, New York City	May 12, 1898
Slipper, Charles J.	Chief Engineer's Office, Manhattan Railway Co., 195 Broadway, Manhattan, New York City	Jan. 10, 1901
Southard, George C.	Civil Engineer, Lehigh Gap, Pa.	Jan. 7, 1897
Strachan, Joseph	Assistant Engineer, Dept. of Water Supply, Brooklyn, New York City	Oct. 9, 1896
Strachan, Robert C.	Assistant Engineer, Dept. of Bridges, Park Row Building, Manhattan, New York City	Jan. 12, 1899
Swain, Henry S.	878 Driggs Ave., Brooklyn, New York City	June 24, 1897
Swezey, Edwin C.	Civil Engineer and City Surveyor, Third Ave. and 39th St., Brooklyn, New York City	Nov. 6, 1896
Taylor, Thomas Walter	With Manhattan Railway Co., 195 Broadway, Manhattan, New York City	Jan. 10, 1901

Name.	Address.	Date of Election.
Tillson, George W.	Assistant Engineer, Dept. of Highways, Brooklyn, New York City	Oct. 9, 1896
Tooker, Frank W.	Assistant to Charles W. Leavitt, Jr., 15 Cortlandt St., Manhattan, New York City	Oct. 12, 1899
Torrance, Kenneth	Chief Engineer, Ridgewood Pumping Station, Brooklyn, New York City	Nov. 6, 1896
Trout, Charles E.	Pier A, North River, Manhattan, New York City	Oct. 12, 1899
Tuttle, Arthur S.	Assistant Engineer, Dept. of Water Supply, Brooklyn, New York City	Oct. 9, 1896
Tuttle, Willard S.	Superintendent, Tuttle and Bailey Mfg. Co., 83 North 10th St., Brooklyn, New York City	May 6, 1897
Tyler, Walter L.	A. B. See Mfg. Co., 116 Front St., Brooklyn, New York City	Jan. 11, 1900
Upright, James B.	Superintendent, American Mfg. Co., Noble St. and East River Brooklyn, New York City	April 1, 1897
Vail, Frederic N.	Superintendent, Alcatraz Asphalt Co., 2 Bryson Block, Los Angeles, Cal.	Jan. 7, 1897
Van Buskirk, Clarence R.	Assistant Engineer, Dept. of Highways, Brooklyn, New York City.	Jan. 7, 1897
Wagner, Bernard M.	Assistant Engineer, Dept. of Water Supply, Brooklyn, New York City	Oct. 9, 1896
Walker, Frederick W.	Westinghouse, Church, Kerr & Co., Grand Rapids, Mich.	May 6, 1897
Waterman, Marcus B.	Assistant Electrician, Am. Tel. and Elec. Subway Co., 55 Duane St., Manhattan, New York City	Jan. 11, 1900
Wheeler, Ralph N.	Assistant Engineer, N. Y. Rapid Transit R. R. Com., 13 Astor Pl., Manhattan, New York City	Jan. 12, 1899
Whipple, George C.	Biologist and Director of Mt. Prospect Laboratory, Dept. of Water Supply, Brooklyn, Flatbush Ave. and Eastern Parkway, Brooklyn, New York City.	Oct. 13, 1898

Name.	Address.	Date of Election.
WHITE, E. SHERMAN	Engineer, Dept. of Buildings, Lighting and Supplies, Brooklyn, New York City	Nov. 6, 1896
WILLIAMS, CHAUNCEY G.	Assistant Engineer, New East River Bridge, 84 Broadway, Brooklyn, New York City	Oct. 13, 1898
WILLIAMS, RICHARD L.	Civil Engineer and City Surveyor, 191 Montague St., Brooklyn, New York City	Nov. 6, 1896
WILLS, J. LAINSON	Chemist, National Brewing Academy and Chemical Industry, 39 South William St., Manhattan, New York City	Jan. 6, 1898
WINSLOW, GEORGE E.	Assistant Engineer, Dept. of Sewers, Brooklyn, New York City	Nov. 6, 1896
WOOD, NOBLE W.	Bacon Air Lift Co., 100 Broadway, Manhattan, New York City	May 6, 1897
WOODWARD, FREDERICK S.	Edison Electric Illuminating Co., 360 Pearl St., Brooklyn, New York City	June 24, 1897
WREAKS, HUGH T.	Mechanical Engineer, Chain Belt Co., 15 Cortlandt St., New York City	Apr. 14, 1898
WYNKOOP, HUBERT S.	Electrical Engineer, Dept. of Buildings, Lighting and Supplies, Brooklyn, New York City.	Feb. 4, 1897

ASSOCIATE MEMBERS.

ANGELL, CHARLES A.	Supt. Cranford & Co., 215 Montague St., Brooklyn, New York City	Apr. 12, 1900
BAILLIE, ELLIS H.	Secretary, Wilson & Baillie Mfg. Co., 85 Ninth St., Brooklyn, New York City, N. Y.	June 24, 1897
BATES, FRANK C.	Assistant Engineer, Dept. of Sewers, Brooklyn, New York City	June 24, 1897
CALDWELL, JOHN R.	Lidgerwood Mfg. Co., Brooklyn, New York City	Oct. 12, 1899
COESTER, EMIL	Draughtsman, Dept. of Sewers, Brooklyn, New York City	Jan. 7, 1897

Name.	Address.	Date of Election.
Cranford, Frederick L.	Cranford & Co., 215 Montague St., Brooklyn, New York City	Apr. 14, 1898
Cranford, Walter V.	Cranford & Co., 215 Montague St., Brooklyn, New York City	Apr. 14, 1898
Cregin, Charles A.	Contractor, 40 Court St., Brooklyn, New York City	June 24, 1897
Demarest, Henry S.	With Greene, Tweed & Co., 17 Murray St., New York City	June 24, 1897
Driggs, Clifford V	With H. P. Read Lead Works, 645 Lexington Ave., Manhattan, New York City	March 9, 1899
Gellatly, Edward S.	Patterson-Sargent Co., 42 Hudson St., Manhattan, New York City	Jan. 11, 1900
Grinden, William J.	Secretary, J. H. Williams & Co., Richards and Bowne Sts., Brooklyn, New York City	June 24, 1897
Hann, John	General Contractor, 189 Montague St., Brooklyn, New York City	Oct. 12, 1899
Hastings, Charles L.	Patterson-Sargent Co., Boston, Mass	May 6, 1897
Kay, Samuel H.	Draughtsman, Henry R. Worthington Co., P. O. Box 14, Brooklyn, New York City	Jan. 10, 1901
Kearns, William F.	Dept. Highways, Municipal Building, Brooklyn, New York City.	Jan. 11, 1900
Kelly, John A.	62 Beard St., Brooklyn, New York City	March 4, 1897
Koller, Winfield R.	293 Broadway, New York City	April 1, 1897
Magrath, James W.	Assistant Engineer, Dept. of Sewers, Brooklyn, New York City	June 24, 1897
Markey, William A.	Leveler, Dept. of Sewers, Brooklyn, New York City	June 24, 1897
Southworth, Frank G.	Traffic Chief, N. Y. & N. J. Tel. Co., 81 Willoughby St., Brooklyn, New York City	Jan. 6, 1898
Squires, William H.	Agent, 91 John St., Manhattan, New York City	April 14, 1898
Thomas, Thomas H.	President, Eastern Bermudez Asphalt Paving Co., 11 Broadway, Manhattan, New York City	Jan. 12, 1899

Name.	Address.	Date of Election.
Tice, George, Jr.	Draughtsman, Dept. of Buildings, Lighting and Supplies, Brooklyn, New York City	Jan. 7, 1897
Voorhees, Stephen F.	With Wm. P. Field, C. E., Newark, N. J., 80 Joralemon St., Brooklyn, New York City.	Jan. 10, 1901
Warner, Elmer E.	Electrical Engineer, 103 Sterling Place, Brooklyn, New York City	Jan. 10, 1901
Weiderman, George	With Geo. Weiderman & Co., Electrical Engineers and Contractors, 267 Flatbush Ave., Brooklyn, New York City	Nov. 9, 1899

NON-RESIDENT MEMBERS.

Crane, Albert S.	Asst. Chief Engineer, Am. Lake Superior Power Co., Sault Ste. Marie, Mich.	Oct. 9, 1896
Darbee, William	Local Manager, Connecticut Lighting and Power Co., South Norwalk, Conn.	Jan. 6, 1898
Legaré, Bailie Peyton	36 Victoria St., London, S. W., England	Apr. 14, 1898
Pierce, Frederick E.	Asst. Supt., Oxide Dept., Newark Works, New Jersey Zinc Co., Passaic Ave., Newark, N. J.	Oct. 9, 1896
Rowell, George F.	Asst. Engr., Penn. Water Co., 701 Wood St., Sta. D, Pittsburg, Pa.	Nov. 6, 1896
Tenney, Willis R.	Asst. Engineer, Dept. of Havana, Tacon 3, Havana, Cuba	Jan. 7, 1897
Wilkins, I. Chester G.	726 Equitable Building, Baltimore, Md.	Jan. 7, 1897

PROCEEDINGS OF THE FOURTH ANNUAL MEETING

HELD AT

THE OXFORD CLUB, BROOKLYN, DECEMBER 13th, 1900.

President George W. Tillson called the meeting to order at 9 P. M. The reading of the minutes of the last meeting, November 8th, was dispensed with.

The Secretary presented the Annual Report of the Board of Directors, with which was transmitted the Annual Reports of the Officers and Committees, which was then read as follows:

REPORT OF THE BOARD OF DIRECTORS.

BROOKLYN, N. Y., DECEMBER 13TH, 1900.

To the Members,

BROOKLYN ENGINEERS' CLUB.

Gentlemen,—The Board of Directors herewith presents its Fourth Annual Report:

The work of the Club has been carried on in practically the same way as has been so successful in the past. The labors of the Board have been much simplified by the prompt action of Committees and the generous responses from the members to all calls for special work.

Meetings.—During the past year there have been held eight regular meetings, and twenty informal Thursday night talks, in the Club library. While the attendance at these meetings has been good and compares favorably with that of former years, it seems to the Board that it would be much increased if all the members fully appreciated the advantages to be derived from a regular attendance. The Thursday night talks are given by specialists in their respective lines, and have always proven of great benefit to the members present. The average attendance for the year has been forty-two for the regular meetings, and seventeen for the Thursday night talks. By referring to the reports of other engineering clubs, it will be seen that this latter attendance compares favorably with that of these clubs at their regular meetings.

Committee Work.—The success of the Club depends in a very great measure upon the work of the different Committees, and the Board

feels justified in calling the particular attention of the members to what has been done in this direction.

Entertainment Committee.—It has been the duty of this Committee to provide technical papers and to make all arrangements for regular and special meetings, such as the June dinner given annually to the ladies. This meeting was held in 1900 at the Brighton Beach Hotel, and, notwithstanding the severe storm, was the best attended and one of the most successful ever given by the Club. Eight papers have been furnished by this Committee during the year, each one being a credit to the Club and the member who prepared it.

Membership Committee.—This Committee has examined and reported promptly upon the credentials of all applicants for membership, the number reported on being eleven for corporate and six for associate membership.

Library Committee.—This is one of the important Committees of the Club. Its duty is to take general charge of the Club library, reporting to the Board of Directors what books it is advisable to purchase, as well as any other recommendation it may deem necessary. It has provided a card catalogue of the books in the library, but on account of a lack of room it has not been completed, as any list made now would be rendered useless under a rearrangement of shelves, which it is hoped may be brought about soon. The work of the Committee has become so great that a Librarian has been deemed necessary to take immediate charge of the library, under the direction of the Committee, and an amendment to the Constitution making provision for this officer has been submitted to the Club, and it is hoped will be passed at the Annual Meeting. This Committee has also inaugurated and carried out the system of Thursday night talks previously referred to.

Excursion Committee.—Under the direction of this Committee excursions have been made to prominent engineering works in and about the city. These have all proven of great interest and value to the members, and a source of real benefit to all who could attend. The Committee has been somewhat hampered in its work on account of the enforced resignation of its first chairman.

Publication Committee.—The work of this Committee consists in preparing for the printer the papers that have been read before the Club during the year, and all other matter for the annual publication. You have all received a copy of the publication, and its general character, as well as that of the individual papers, reflects credit upon every one concerned in its preparation. Too much praise cannot be given to this Committee for its painstaking labor, which has resulted not only in a creditable book, but an addition of nearly two hundred dollars to the Club treasury. The reports of all these Committees will be published in full, and should be carefully read by every member of the Club.

Membership.—By a reference to the report of the Secretary, it will be seen that the total membership of the Club at the present time is 162, an increase of three over that of last year. This seems small when compared with previous years, but it must be remembered that the Club draws for its membership wholly upon this immediate vicinity, and in the future cannot expect to increase very rapidly. There are, however, eight applications for membership to be acted upon at the January meeting.

The Board reports with sorrow the death of one of the corporate members, Mr. Peter C. Jacobsen, who died on March 12, 1900.

Finances.—In accordance with a provision of the Constitution, the Board has audited the accounts of the Secretary and Treasurer, and has found them correct. The following is the substance of the audit:

RECEIPTS.

From dues, 160 members, all classes		$1,187 00
" initiation fees		70 00
" Annual publication		929 00
Dinners and collations		218 00
Interest on daily balances		19 79
		$2,423 79

EXPENDITURES.

Brooklyn Library, on account of contract		$447 00
Postage and stationery		145 64
Janitor's services		24 00
Typewriting and stenography		85 00
Meetings and entertainments		450 53
Publication Committee expenses		769 57
Excursion Committee expenses		2 10
Secretary's salary		300 00
Library furniture		50 94
Telephone		21 25
Total		$2,296 03
Making net revenue for year	$127 76	
Balance, December 5, 1899	784 24	
Amount deposited with Franklin Trust Co. at this date		$912 00

Of the above, $29 should be credited to the 1899 account. There are now also due for collations, advertising and annual dues, $132.50. If all is collected, the net revenue for the year will be $231.26, against $190.75 for 1899.

The present system for paying for collations leaves a considerable

amount due the Club on December 1st. This, however, is collectible with the annual dues.

The Board desires to thank all Committees and members of the Club for their efficient work, which alone has made the above showing possible.

Very respectfully,
GEO. W. TILLSON,
A. J. PROVOST, Jr.,
C. W. RICE,
WALTER M. MESEROLE,
HENRY B. SEAMAN,
Board of Directors.

The reports referred to above are given in the following

APPENDIX.

REPORT OF THE SECRETARY.

OFFICE OF SECRETARY, 191 MONTAGUE STREET,
BROOKLYN, N. Y., DECEMBER 1ST, 1900.

To the Board of Directors,
BROOKLYN ENGINEERS' CLUB.

Gentlemen:—The Secretary has the honor to submit the following as his report:

The roll of the Club, at the date of the last Annual Report (December 5th, 1899), contained 159 names, classified as follows:

Corporate members	128
Associate members	23
Non-resident members	7
Honorary member	1
Total for 1899	159

There have been added during the past year by election, 11 Corporate members and 3 Associate members, and 1 Corporate member restored to membership. There have been 2 Corporate members transferred to the Non-resident grade. There have been lost during the past year, by death, 1 Corporate member; by resignation, 5 Corporate members, 2 Associate and 2 Non-resident members; dropped from the rolls for non-payment of dues, 2 Corporate members. Making the present total membership:

Corporate members	130
Associate members	24
Non-resident members	7
Honorary member	1
Total for 1900	162

There have been held during the past year 8 regular meetings, with a total attendance of 336.

The receipts of the Club during the fiscal year ending December 13th, 1900, have been as follows:

From dues and initiation fees	$1 257 00
From dinners and collations	218 00
From Annual Publication	929 00
Total	$2 404 00

These funds have been collected by the Secretary and paid over by him to the Treasurer for deposit to the credit of the Club.

There is outstanding and uncollected at the present time the following amounts:

On account of dues	$9 00
On account dinners and collations	53 50
From advertisers, Annual *Proceedings*	70 00
Total outstanding	$132 50

This is probably collectible and should be credited as an asset in balancing the past year's record.

The Secretary desires to thank the Board for its hearty support in all matters connected with his office, and especially for its prompt action in taking steps to relieve the Secretary, at his request, of the cares of the library, which work, as your Board understands, was voluntarily assumed by the Secretary at the organization of the Club, and has since then commanded at all times his deep interest. It is hoped that the Club will act favorably upon the constitutional amendment instituted by your Board, creating the office of Librarian. In the hands of a competent officer with no other demands upon his leisure time, the growth and usefulness of the library should show material gain over that which the Secretary, in spite of his deep interest, has been able to accomplish.

It is further to be hoped that the Club will act favorably upon the amendments to the Constitution, instituted by your Board, defining more exactly the duties of Secretary and Treasurer, as it has been found necessary by your Board to designate them.

The Secretary takes this opportunity to thank the members of the Club for the general promptness displayed in the payment of Club charges, thereby greatly facilitating the work of his office.

Respectfully submitted,

A. J. Provost, Jr.,
Secretary.

REPORT OF THE TREASURER.

BROOKLYN, N. Y., DECEMBER 8TH, 1900.

To the Board of Directors,
BROOKLYN ENGINEERS' CLUB.

Gentlemen:—Your treasurer begs to submit the following statement, covering a period from December 1st, 1899, to December 1st, 1900, as follows:

Calvin W. Rice, Treasurer, in account with the BROOKLYN ENGINEERS' CLUB.

DR.

Balance from December 1st, 1899	$784 24	
Received from the Secretary, December 1st, 1899, to December 1st, 1900	2 404 00	
Interest accrued	19 79	
		$3 208 03

CR.

Payments from December 1st, 1899, to December 1st, 1900, on warrants from the Secretary and approved by the President	$2 296 03	
Balance to new account	912 00	
		$3 208 03
Balance on hand December 1st, 1900		$912 00

Respectfully submitted.

CALVIN W. RICE,
Treasurer.

REPORT OF THE ENTERTAINMENT COMMITTEE.

BROOKLYN, N. Y., DECEMBER 12TH, 1900.

To the Board of Directors,
BROOKLYN ENGINEERS' CLUB.

Gentlemen:—The Entertainment Committee of the Brooklyn Engineers' Club begs to submit the following report for the year ending December 31st, 1900.

In assuming its duties, your Committee noting how well adapted to the requirements of the Club were the rooms in the "Argyle," the monthly meetings were continued to be held there on the same terms as were previously in force, namely, $10 per evening for the use of rooms, and each member paying for individual collation account semi-annually on a statement from the Secretary.

The papers provided by the Committee and presented before the Club have been as follows:

January.—" The Plane Table," by C. D. Pollock.

January.—" Some Experiments on the Bacterial Purification of Sewage," by A. J. Provost, Jr.

February.—" A Short Talk on Landscape Engineering," by Robert J. Beach.

March.—" The Action of Water on Asphalt," by Daniel D. Jackson, George C. Whipple.

April.—" Mt. Prospect Laboratory," by George C. Whipple.

May.—" Drop Forgings," by William J. Grinden.

October.—" The Electric Conduit Railway: Its Development and Construction," by Frank G. Cudworth.

November.—" Burning of City Wastes: When and Where Advisable," by Macdonough Craven.

The papers were nearly all illustrated by lantern photographs, as this method gives a clearer conception of intricate arrangements of material forms, simplifying and shortening descriptions, leaving more space for other matter. The Committee is under obligations to Mr. F. A. Drake, who volunteered his services in operating the lantern at some of the meetings.

The summer meeting of the Club, the usual dinner tendered the ladies, was held June 14th at the Brighton Beach Hotel. The popularity of these meetings was demonstrated, for in spite of a severe rain storm during the afternoon and evening, there were present about 70 persons. The Committee wishes to express its indebtedness to the Brooklyn Rapid Transit Company for its courtesies rendered in connection with this dinner.

In the matter of finances the Treasurer and Secretary has the thanks of the Committee for having relieved it of all routine duties of payments and collections; hence in this connection their respective reports are referred to your consideration.

Respectfully submitted,

WILLARD S. TUTTLE, *Chairman.*

W. V. CRANFORD,

H. S. DEMAREST,

Entertainment Committee.

REPORT OF THE LIBRARY COMMITTEE.

BROOKLYN, DECEMBER 13TH, 1900.

To the Board of Directors,

BROOKLYN ENGINEERS' CLUB.

Gentlemen:—The Library Committee reports its work for the year ending December 13th, 1900, to have been as follows:

We have taken general charge of the rooms and library secured to

the Club by contract made with the Brooklyn Library by your Board in the early part of the year.

The card catalogue of the books in the library has been completed, so far as entering the titles of books on cards under suitably headed guide cards and placing same in the cabinet purchased for that purpose, but the book numbers and shelf numbers have not yet been filled in.

The increase in the number of books in our portion of the library has quite overrun the shelf capacity at our disposal. A plan to place a line of shelves along the only available side of our library room was proposed early in the year but has not yet been carried out. The first estimates of the cost of this proposed shelving were thought too high; later the Brooklyn Library took the matter up and were to put in the shelving, charging the cost of same to the Club, but the work has not yet been done.

This shelving, if built, would prove but a temporary relief, and later recourse must be had to book stacks, which will materially reduce the available space for readers, as well as make all but impossible the continuance of the informal Thursday night meetings in that room.

In view of this state of affairs, it is suggested that your Board endeavor to secure from the Brooklyn Library any additional space suitable for the growth of the Club library that may be available for that purpose.

In the meantime it seems desirable to leave uncompleted the card catalogue until it is definitely known just what course will be pursued as to future accommodation, for the rearrangement of the catalogue made necessary by a change in the plans for shelving, etc., would be most undesirable as well as expensive.

The accession book and the listing of desirable books for purchase by the Brooklyn Library has been continued as before.

The additions to the library during the year have been as follows:

By Purchase:

Standard Reference Works, 69 vols., at a cost of.......	$163 16
Periodicals (binding included), 90 vols., at a cost of....	301 80
Total, 159 vols....................................	$464 96

By Donation:

Bound volumes.............	24
Unbound "	32
Pamphlets (reports, etc.)...	59 vols. and 35 numbers of periodicals incomplete.
Total accession........	274 volumes and 35 numbers of periodicals incomplete.

Total number of volumes in the library at this day, 2 901.

In presenting herewith a statement of the donations received during the year, the Committee desires to express its thanks to all the donors named, and particularly to:

Messrs. R. D. Dodge and B. G. Braine for their very valuable gifts; R. D. Dodge, 9 volumes and 44 pamphlets; B. G. Braine, 5 volumes and 122 pamphlets, including incomplete periodicals; through Brooklyn Library, 6 volumes and 9 pamphlets; International Association for Testing Materials, 16 pamphlets; United States War Department, 6 volumes; R. Shermerhorn, Jr., 5 pamphlets; G. C. Whipple, 4 pamphlets; A. J. Provost, Jr., 3 pamphlets; W. P. Gerhard, 5 pamphlets; Ohio State Board of Health, 2 volumes and 5 pamphlets; United States Department of Agriculture, Brooklyn Rapid Transit Company, Peter Milne, Pratt Institute, Metropolitan Sewerage Commission, Mass.; B. H. Sturtevant Company, Mass.; Gas and Electric Light Commissioners, Construction News, 2 volumes each; Aluminum World, G. C. Whipple and D. D. Jackson, Coldwell Wilcox Company, United States Government Printing Office, Progressive Age, Stone, Col. J. N. Partridge, W. J. Baldwin, W. H. Roberts, Goheen Manufacturing Company, Rawson & Morrison Manufacturing Company, L. G. Carpenter, New York and New Jersey Telephone Company, J. G. Ould, Brooklyn Engineers' Club, New Jersey Public Roads Commission, Flush Tank Company, Association Civil Engineers Cornell University, Public Improvements, Bird S. Coler, E. L. Corthell, Geo. W. Tillson, H. K. Wreaks, N. P. Lewis, United States Geological Survey, 1 volume each. Buffalo Pan-American Exposition, 12 photographs.

Attention is again called to the desirability of completing our files of periodical literature by means of donations to the Club by members who have back numbers which they can conveniently spare from their private collections.

The list of bound volumes as published in the catalogue of the library, January 1, 1901, will inform members which volumes are incomplete.

The informal Thursday night discussions at the library room have been continued throughout the year.

The topics discussed during the year are as follows:

Jan. 18th. "Enginering Features of National Guard Work," B. M. Wagner.

" 25th. "The Venturi Meter," John H. Meyers, Jr.

Feb. 1st. "Elevator Safety Devices," Allan Cowperthwait.

Feb.	15th.	"Electric Car Heating," F. L. Evans.
Mar.	1st.	"Heating and Ventilating Modern Buildings," William J. Baldwin.
"	15th.	"Some American Bridges for Japan," Bernt Berger.
"	22d.	"Landscape Gardening," A. J. Provost, Jr.
"	29th.	"Moon Island Outfall, Boston Main Drainage Works," C. E. Trout.
April	5th.	"Railroad Masonry," D. F. Carver.
"	19th.	"Technical Education." Topical Discussion.
"	26th.	"Methods of Keeping Private Engineering Indexes." Topical Discussion.
May	3d.	"Paint for Metallic Structures," E. S. Gellatly.
"	17th.	"Portland Cement Concrete as a Material of Construction." Topical Discussion.
May	24th.	"High Explosives and Smokeless Powders," Dr. W. M. Hutchinson.
Oct.	18th.	"Water Meters," John W. Norris.
"	25th.	"Architectural Engineering," V. C. Griffith.
Nov.	1st.	"Concrete," G. W. Tillson.
"	15th.	"Types of Bridge Erection," F. W. Skinner.
"	22d.	"Electricity in Mining Operation," C. W. Rice.
Dec.	6th.	"Testing of High Duty Pumping Engines," W. C. Brown.

The average attendance at the library meetings held during the past year has been seventeen, varying from a minimum of ten members, who attended one of the meetings in spite of a severe snow storm, to a maximum of twenty-two members present.

These "talks" cover a wide range of subjects and have proven of great interest and induced a free and thorough discussion by the members who attended.

It has been the policy of the Library Committee to have no record kept of the Thursday night discussions other than the subject discussed and the name of the principal speaker for the occasion.

In this way it has been found possible more easily to induce a member or a friend of the Club to speak of the special work with which he was familiar, where if a carefully written paper for record was asked for he would often find it inconvenient or undesirable to yield to the request.

In many cases speakers have, in view of the great interest shown at these meetings, indicated a willingness to enlarge upon a particular subject in a formal paper for one of the regular monthly meetings of the Club.

Of the seventeen principal speakers named above, it is of some interest to note that five of that number are not now members of the Brooklyn Engineers' Club, and it is suggested to the members of the

Club generally, that each one be alert to locate speakers and subjects that would prove of interest to the membership for these Thursday night discussions, and communicate promptly such information to the Library Committee.

Referring to the contract made by your Board with the Brooklyn Library, the Committee reports as follows:

The Brooklyn Library has received from the Club...		$447 00
and has expended upon the recommendation of the Committee:		
For new books..........................	$163 16	
For periodicals and bindings*............	189 30	
		352 46
Leaving a balance on account of contract amounting to....................................		$47 54

which will be more than covered by the cost of shelving, which will no doubt be completed before the termination of the present contract.

Your Committee respectfully recommends that the necessary steps be taken to secure the continuance of present arrangement with the Brooklyn Library as to library privileges before expiration of present contract, February 1st, 1901.

Your Committee is of the opinion that there will be needed during the coming year two hundred dollars ($200) for the purchase of new books and two hundred dollars ($200) for periodicals classified as new, with bindings, a total of four hundred dollars ($400), which sum should be arranged for in any contract with the Brooklyn Library which your Board shall make. There should be set aside from the funds of the Club the sum of twenty-four dollars ($24) for the services of janitor during the coming year, and sixty dollars ($60) for expenses of giving notices of Thursday night meetings.

The telephone service at the library was, by a modified agreement with the Telephone Company, made early in the year, continued under an arrangement most satisfactory to the Club. The service is now without expense to the Club, except for actual messages sent. It is believed that members will appreciate the convenience and continue to make use of it in connection with their library work.

The Committee desires to express its appreciation of the uniform assistance and courtesies received at the hands of the Librarian of the

* Periodicals subscribed for prior to October 1st, 1895, together with bindings for same, are not included in this item.

Brooklyn Library and his staff. Also to thank your Board for the kindly interest shown in the Committee's work during the year.

Respectfully submitted,

JOSEPH STRACHAN, *Chairman.*
J. CALVIN LOCKE,
A. J. PROVOST, JR.,
Library Committee.

REPORT OF THE MEMBERSHIP COMMITTEE.

BROOKLYN, N. Y., DECEMBER 1ST, 1900.

To the Board of Directors,
BROOKLYN ENGINEERS' CLUB.

Gentlemen:—The Membership Committee of the Brooklyn Engineers' Club herewith respectfully submits the following report of its transactions during the past year.

Your Committee has considered and acted favorably upon the application of eleven candidates for admission to the grade of Corporate Member and six applications for Associate Membership.

We are pleased to state that after careful consideration we were able to attest to the qualifications and eligibility of all the above applicants, and feel that their election and interest in the Club will prove an additional source of strength to the organization.

We recommend that every member put forth some effort to increase our numbers with desirable candidates.

It would greatly facilitate the labors of your Committee if the blank forms sent to the vouchers of an applicant were promptly filled out and forwarded to its Chairman.

We desire in conclusion to tender our sincere thanks to your Board and the Secretary for the uniform courtesy and consideration received.

Respectfully submitted,

WM. T. BRUORTON, *Chairman.*
E. C. SHALER,
F. G. CUDWORTH,
Membership Committee.

REPORT OF THE EXCURSION COMMITTEE.

BROOKLYN, N. Y., DECEMBER 1ST, 1900.

To the Board of Directors,
BROOKLYN ENGINEERS' CLUB.

Gentlemen:—The Excursion Committee has the honor to report for the year just ending the following:

That in February, through the courtesy of Mr. F. W. Conn, Superintendent of the New York and New Jersey Telephone Company, a

large number of the members of the Club visited and inspected the plant of the Telephone Company, at 81 Willoughby Street, Brooklyn. (February 28th.)

Early in the summer Messrs. Cranford & Company gave the Club permission to visit and inspect its plant for the disposal of New York City garbage on Barren Island. Through the courtesy of the Brooklyn Rapid Transit Company, transportation was furnished from City Hall to Jamaica Bay, from which point a large number of members were conveyed by special steamer of the Cranfords to Barren Island. Messrs. W. V. & F. W. Cranford and Mr. M. Craven, of this Club, conducted the party and explained in detail all the various stages of the process. (July 14th.)

By permission of Chief Engineer George H. Pegram of the Manhattan Elevated Railroad, leave was granted to visit the new power plant on the East River, at Seventy-fourth Street.

Mr. Frank G. Cudworth, of the Club, conducted the party and explained in detail all the points of interest, including special concrete construction. (September 15.)

Through the courtesy of Mr. Calvin W. Hendrick, Division Engineer on the Rapid Transit Commission, permission was given to the Club to visit the Bellmouth, at Fifth Avenue and One Hundred and Tenth Street, besides some sewer construction necessitated by the rapid transit work. (November 17th.)

The Committee feels that the Club is much indebted for the courtesies extended to its members.

It would recommend that it be informed from time to time of the existence of special engineering work which any member may consider of sufficient general interest to warrant an excursion.

Respectfully submitted,

William G. Ford, *Chairman.*
J. C. Meem,
Ralph N. Wheeler,
Excursion Committee.

It was regularly moved and seconded that the Annual Reports of the Board of Directors, of Officers and Committees be received, accepted and ordered published in the forthcoming *Proceedings* of the Club. (Carried.)

The President announced for ballot the proposed Constitutional Amendments creating the office of Librarian and defining his duties and method of election.

Upon motion, duly seconded, the Secretary was authorized to cast one ballot as the vote of the meeting for the adoption of the amend-

ments as printed. The Secretary having announced that ballot cast, the amendments were declared adopted.

The President then announced for discussion the proposed constitional amendments filed with the Secretary November 13th and December 5th, printed copies of which had been regularly submitted to each Corporate member.

It was regularly moved and seconded that the proposed amendments be passed up for ballot as amended. (Carried.)

The President here announced as the next order of business the election of officers for the ensuing year, nominations for which had been presented by the Nominating Committee and announced at the November meeting as follows: For

President, JOSEPH STRACHAN.
Vice-President, WILLARD S. TUTTLE.
Secretary, ANDREW J. PROVOST, JR.
Treasurer, GEORGE C. WHIPPLE.

In the absence of further nominations, he declared a ballot in order and appointed Messrs. Jackson and A. I. Perry tellers to canvass the vote.

A ballot was then taken. The tellers' report showed 39 ballots cast, of which

Joseph Strachan received 39 votes for President.
Willard S. Tuttle " 39 " for Vice-President.
Andrew J. Provost, Jr., received 39 votes for Secretary.
George C. Whipple " 39 " for Treasurer.

The candidates were therefore declared duly elected.

Mr. Tillson then addressed the meeting as follows:

PRESIDENT'S ADDRESS.

By GEO. W. TILLSON.

The passing of the year 1900 has made possible the writing of another chapter in the history of our Club. It has also made it incumbent upon me to render an account of my stewardship. I am glad that I can say that the reports made to the Board of Directors at a recent date, a synopsis of which has already been presented to you, shows the affairs of the Club to be in a flourishing condition, and that, generally, it has maintained within the past year the standard which it had attained in previous years. But, do not think for a moment that I, or the other members of the Board of Directors, think that this state of affairs is due to our efforts, because, it seems to me, that the workings of this Club are very similar to, and can be compared with, those of a steam engine, where the officers are the engineer, the committees are the machinery, and the members generally furnish the

fuel. No matter how good the engineer may be, no matter how well he may have the machinery in hand, unless the fuel is good and properly applied he cannot attain the full efficiency of his engine. So, I say to you that the credit primarily is due to the members of the Club themselves; but the Club must not resolve itself into a mutual admiration society, because it must be distinctly understood that these results are not attained without the earnest effort of every member of the Club. As the engineer, when he is about to submit his engine to a crucial test, goes carefully over all its parts, lubricating every bearing, testing every cock, trying every valve, adjusting every screw to see that all is complete and in good working order; as the fireman down in the stoke hole is watching every fire, scattering a little fuel into this box, shoveling it into that, in order that the combustion may be as nearly complete as possible, so must the Board of Directors supervise the work of the committees, and the committees in their turn look to the members of the Club. They must understand each member, know just how much and how little they shall demand of each individual, and then we will have a result which has been obtained by very few clubs of any sort.

It has been said, or rather was said when this Club was first organized, that there was no room for it; that it could not live; that we were too near that great and national society of Civil Engineers that has its headquarters in Manhattan; but any one who looks back over our history, who reads the papers that have been published in our *Proceedings*, must admit that there was not only room for this organization, but there was a demand for it, and that the demand has been met. And it seemed to me that this was due to a great extent to the fact that the object of the Club was to disseminate knowledge among its members. It was not to exploit the knowledge of any single member, and I am glad to say that there never has been a time when any member of this Club had any fear of asking any question, no matter how elementary it might have been.

Three years ago, when I made a few remarks before this Club at our Annual Meeting, I said that in the next 25 years I thought there would be more and greater undertakings projected and carried out within the limits of Greater New York than on any other territory of the same area in the world. Let us look back for a short time and see how the events of the past three years have justified that prediction. We find, first, a bridge nearing completion across the East River whose estimated cost is not less than $18 000 000. We find plans being prepared for another bridge still further down across the same river, whose estimated cost cannot be very much less.

Crossing over into Manhattan there is the bridge projected over the Hudson which is to bring all of the railroads of the West into the heart of Manhattan Island. The estimated cost of this bridge, includ-

ing the terminal facilities, which must be built as part of the project, is not less than $30 000 000. More than that, within the past year we have seen a contract let for and work begun on that great system of underground railroads which eventually is bound to connect every borough of this imperial city, and finally bring what New Yorkers have long wanted, and wanted in vain, real rapid transit.

These few projects which I have enumerated—and I might add the projected connection from Manhattan to Brooklyn, whose cost is $9 000 000—these four projects make a grand total of $110 000 000. Now, gentlemen, these figures are astounding, and alongside of them a sewer contract for half a million of dollars, or a paving contract for $100 000, is insignificant; but in these last three years in these two lines there have been many millions of dollars expended; and when we consider further the extension and reconstruction of street car systems and the carrying out of other projects in the city, the work of the Dock and Water Departments, all of which require engineering knowledge and skill, we have a total for work that has been constructed and projected during the last three years that cannot be less than $135 000 000. And I am glad to say that in almost every one of these works that I have enumerated, the members of the Brooklyn Engineers' Club have taken part, and in many of them very prominent parts, and in others our guests have had their share.

Now, gentlemen, in bidding you farewell, as the presiding officer, I wish to tell you, first, how much I have enjoyed the position, and then to thank you, personally and collectively, the other members of the Board of Direction who have served with me, the members of the Committees and the members of the Club, for their hearty co-operation for everything that has been done during the past year; and, now, in saying good-bye, I want to present to you, for he needs no introduction, your new President, Mr. Strachan.

The incoming President, being called upon, responded as follows:

Mr. Joseph Strachan—Gentlemen of the Brooklyn Engineers' Club: I cannot but feel highly honored to be selected from among so many more worthy than I to be the President of the Brooklyn Engineers' Club during the opening year of the Twentieth Century. In looking back over the four years of the life of our organization, one cannot help but feel proud of the progress that has been made, the *esprit de corps* that has grown up among the engineers composing the Club, and the enthusiasm with which all of the work of the Club has been done. As to the coming year it is not likely that the new administration will find it either necessary or desirable to make any radical changes in the policy of the Club. We will continue the line followed by our predecessors. The past year has been as successful as those which preceded it, and with the help of the active and energetic committees

which will in due course be appointed, working for the good of the Club generally, there will be no drop in the grade of the work done.

The Constitution calls for the appointment of committees of three; but it is hoped that every member of the Club will consider himself as a member, *ex officio*, of each of the committees, thereby securing the maximum of work for the Club.

Our meetings have been characterized by great interest in the papers presented, unaccompanied by any captious or hypercritical discussion, and each member has seemed willing to do his part in such a way that makes the retrospect a very pleasant one.

It may be asked, What good is, or can be, accomplished by this banding together of engineers? There is a practical good which must be kept in mind, and that is the raising of the standard of the work we do; and this results from the stimulation of ideas which is caused by the associating with one another, for as "iron sharpeneth iron, so a man sharpeneth the countenance of his friend." In speaking of the work done by engineers, one of the previous speakers has had some rather suggestive remarks to make about the water supply engineers. It is not generally known, I believe (at least I judge from his remarks), that the extensions to the water-works are not paid for from the private purses of the engineers. This may probably be new. Is Mr. Nissen still with us? I am glad to see he has not abandoned "the firing line."

As the hour is growing late, I do not think you care for any long inaugural address. I will simply thank you again for the great honor you have conferred upon me, and assure you all that in the future you will have just as thorough work from me as presiding officer as you have had from me as a member of various Committees.

Mr. Meserole, Chairman of Special Committee, reported that the conferences of the Committee a year ago with the Topographical Bureau of the Board of Public Improvements, New York City, in relation to the exhibition of records affecting bench marks and monuments in this Borough were at last bearing fruit along the lines recommended by the Committee.

The Secretary announced a donation from Mr. James Pilkington of a section of wooden water pipe recently removed from Oliver Street, Manhattan, while changing sewers for the Rapid Transit Tunnel, the donator claiming this to be the first water pipe laid in New York City, it having been laid by the Manhattan Water Company in 1803 to supply houses in the lower part of the city.

A vote of thanks was extended to Mr. Pilkington for his donation, and the Secretary was requested to notify him of the action of the Club.

Mr. Lewis offered a resolution of thanks to the Oxford Club of

Brooklyn for its hospitality, and especially to its President, Mr. Vernon, who showed his good-will and hospitality by being present. The motion was unanimously carried.

It was then moved by Mr. Meserole, and duly seconded, that the thanks of the Club be extended to Mr. Nissen for being present at the meeting and so kindly entertaining the Club. This was also unanimously carried.

The meeting was then regularly adjourned.

BROOKLYN ENGINEERS' CLUB.*

No. 22.

THE PLANE TABLE, ITS USE AND ABUSE.

By C. D. Pollock, Mem. B. E. C.

Presented January 11th, 1900.

The plane table has been in use so long that its various forms are no doubt familiar to most of those here to-night. We need therefore describe the instrument but very briefly in this paper, which is rather a plea for the more general use of the plane table in making topographical surveys than an historical sketch.

The simplest form of plane table is merely a drawing board, mounted on a tripod, having a leveling device, and the alidade consists of a straight edge, with compass sights having the line of sight parallel to the fiducial edge. The more complete outfits have a good telescope in place of the compass sights, and stadia wires for reading distances when desired.

In this country the United States Geological Survey probably makes the most extensive use of the plane table. This Survey is now engaged in making a series of contour maps of the United States on which they will plot geological areas.

The various surveys of the United States Government do not believe in duplicating work if it can be helped, hence, whenever it is possible to do so, the Geological Survey utilizes the primary triangulation of the United States Coast and Geodetic Survey. In the East they find most of the primary triangulation done for them. Along the

* This Club is not responsible, as a body, for the facts and opinions advanced in this publication.

Atlantic Coast they have the fine work of the Coast and Geodetic Survey, then the United States Lake Survey, and finally the numerous State Surveys. They make use of all of the latter that have been made with a sufficient degree of accuracy. In the West, however, the Geological Survey has to make its own primary triangulation. They frequently use the plane table in their secondary triangulation to great advantage.

Having the triangulation, the next thing they do is to plot the initial points on the plane table sheets, each of which covers fifteen minutes of latitude, and fifteen minutes of longitude. The five minute lines are plotted in the office, the scale of this work in the East is generally 1 : 45 000 (about 1 in. to three-quarters of a mile). The plane table used is a very convenient, light affair, the largest 24 in. x 36 in. is made for the above sheet, which is screwed firmly to the table top. There are neither leveling nor tangent screws, but there is a ball and socket joint for quick leveling of the table. Fig. I gives a good idea of the general appearance of this instrument.

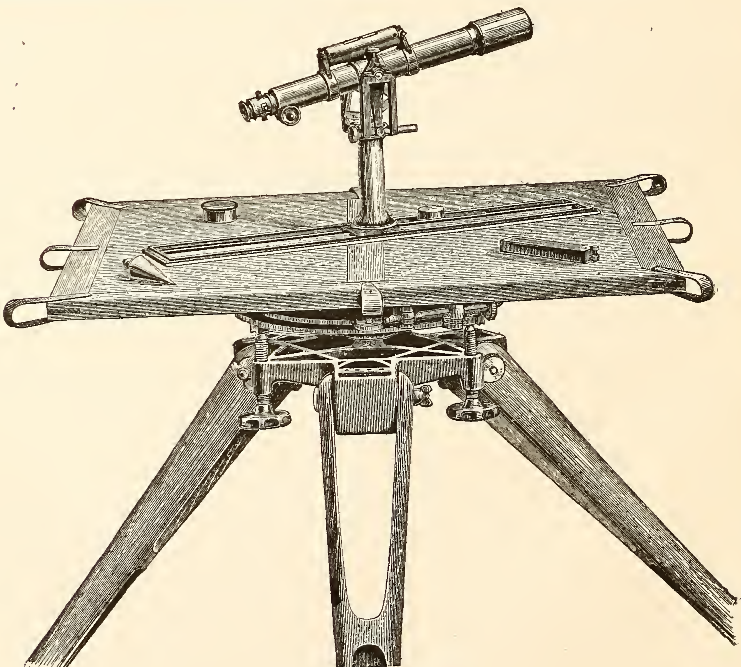


Fig. I.—Plane Table.

Now, we are ready for the plane table parties, the topographer in charge, plane table man, and traverse man. The work is done as far as possible by intersection, and the usual plane table methods.

A smaller sheet containing 7.5 minutes of latitude and 7.5 minutes of longitude on a plane table about 15 ins. square, with small compass for orienting, is used by the traverse man in locating the roads, the distances being measured by means of counting the revolutions of a carriage wheel.

These road traverses are checked on points located on the plane table sheet, and then are transferred to the latter. This seems a crude method, but they get surprisingly accurate results. Contours are sketched on these quarter sheets by the topographer, and these, too, are transferred to the large sheets. The main sheets are inked in at the office, and reduced by photography to a scale of 1 : 62 500, or about 1 in. to the mile. Then the copper plates and lithographic stones are made, and the maps are published.

The United States Coast and Geodetic Survey uses a large, heavy form of plane table on their detail work, and obtains very accurate results.

A number of years ago the United States Light House Establishment made plane table topographical surveys of its property along the North Atlantic Coast, and set boundary monuments. At each Light station a traverse was run with a transit, tide readings were taken and Mean Sea Level, Mean High Water and Mean Low Water were determined, and then benches were established at frequent intervals.

A large plane table was used for the topographical survey, and the plane table sheet used was cloth-backed drawing paper. The transit traverse was plotted very carefully upon the plane table sheet to a scale of 1 : 500 (approximately an inch to 40 ft.), and then the survey was completed upon the plane table sheet. Fathom (6 ft.) contours were located and plotted. Distances to points on contours were measured by stadia.

The party commonly consisted of plane table man (usually in charge), two rodmen with stadia rods (which were also leveling rods), and two contour sketchers. The method of locating contours was as follows: After setting up the table, orienting, and getting the height of instrument from a near-by bench, the proper rod reading for the

contour to be located was figured, and the rodman on either side of the instrument followed out the contour, holding the rod at changes in direction for stadia reading. A sketcher followed and directed each rodman, and sketched the contour between the points where the rod was held, upon sheets of cross-section paper, and at night transferred the contours to the plane table sheet, tieing in by means of the points plotted by the plane table man.

Rapid and remarkably accurate results were obtained by this method. Through the kindness of Mr. Edward P. Adams, the author was enabled to borrow four negatives of Major Stanton, and from them slides were made.

The one of Hendricks Head Light on Southport Island, Me., near the mouth of the Kennebec River, Fig. 2, shows a long, rather flat promontory. Most of the shore lines are granite ledge.

Pemaquid Point (Fig. 3) shows a rather flat beach, with abrupt bank around the lighthouse.

Owls Head, Me., is at the southwest side of the entrance to Penobscot Bay. Here we have a bank that is nearly vertical, rising to over 80 ft. in a very short distance from the water's edge.

Now, outside of these surveys, the plane table seems to be used by but very few engineers in this country, and especially in this part of the country. The author has frequently asked engineers who were locating driveways, and arranging generally artistic layouts of large and small estates, why they did not make use of the plane table, as it would be so much quicker and more economical, but almost invariably the reply has been, "Oh, it would be too inaccurate." But why this idea of the plane table being so inaccurate? It is just as accurate as plotting can be done. A plane table survey can be made to any scale desired. Work can be done in almost any weather in which you would use a transit.

The author knows of a case where a large plane table was used in locating soundings along range lines, and the work was carried on in all kinds of weather by simply having a light shelter erected over the table to keep the rain off the sheet. It seems to the writer that nearly all the abuse of this most convenient and economical instrument comes from those who know very little about the plane table or its uses.

On a large survey, do not use the plane table alone, but make your triangulation with the best instrument for measuring angles that you

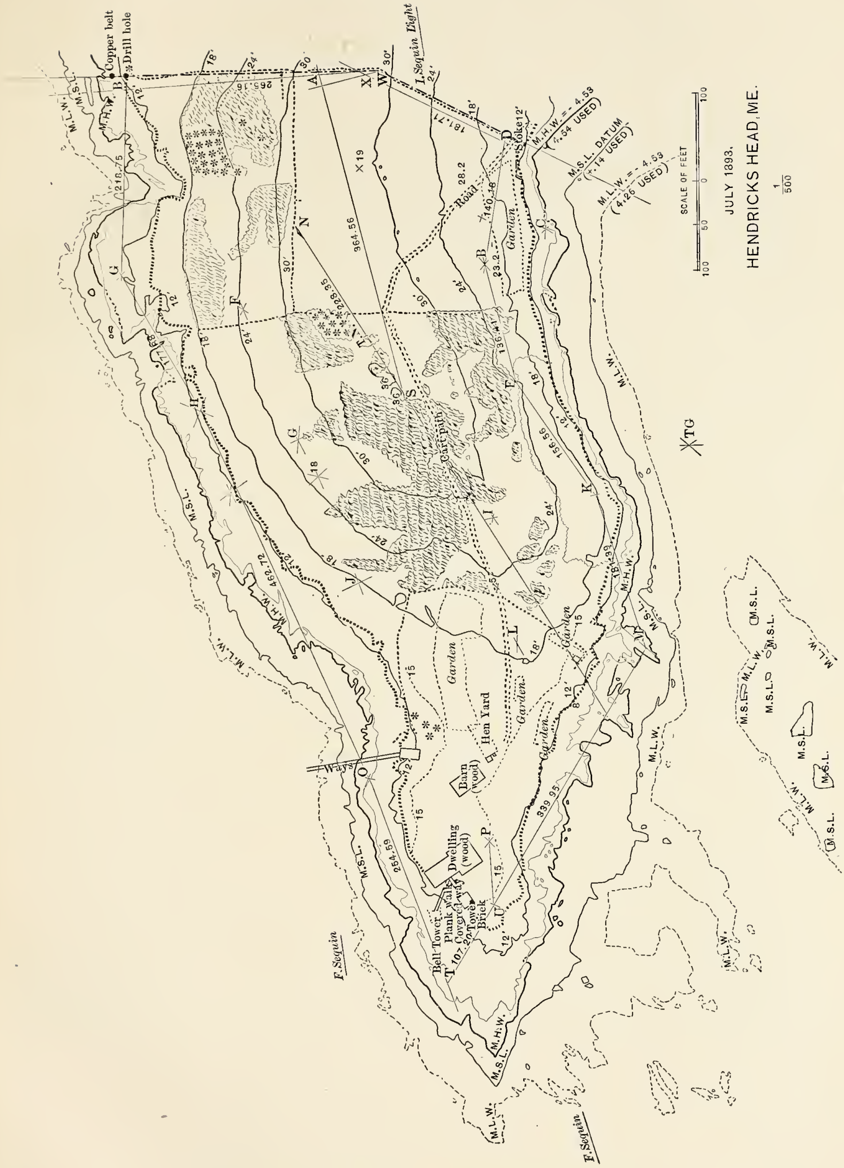


Fig. 2.—Contour Map of Hendricks Head, Maine.

Fig. 3.—Contour Map of Pemaquid Point, Maine.

can get your hands upon. The plane table may be used to advantage in the secondary triangulation, but it certainly can be used to great advantage and economy in the "filling in" of nearly every topographical survey.

In regard to cost of surveys, it has been hard to get comparative figures. The cost of a survey depends a great deal on the amount of monumenting done, the contour interval, the scale, the experience of the men in charge, etc.

For most of the figures presented the author is indebted to Mr. H. M. Wilson, Geographer of the United States Geological Survey.

Baltimore has recently completed a very good survey of the city. Here a great many monuments were set, the contour interval was 3 ft., and a great deal of experimenting was done, steel tape, the theodolite, plane table, etc., were used; cost, about $6 200 per square mile.

St. Louis made a good topographical survey on a scale of 1 : 2 400, or 1 in. = 200 ft. This was made with transit and stadia. Very few monuments were set compared with the Baltimore survey; cost, $732 per square mile. Mr. Wilson estimates that this cost could have been reduced to about $500 per square mile if the plane table had been used.

A topographical survey of Great Britain was begun in 1791 under the Board of Ordnance—this is known as the British Ordnance Survey. The scale used in England was 1 in. to the mile up to 1824, when they stopped and started on Ireland, changing the scale to 6 ins. to the mile. On taking up the survey in England again, the larger scale was adopted. The present general scale there is 1: 2 500. No monumenting was done on this work. Its cost was about $294 per square mile. Most of this work was done with theodolite, stadia and chain. This cost was practically all for the "filling in" as very little triangulation has been included. The British Government made a trigonometrical survey of India on a scale of 1 in. to the mile, supplemented by scales of 4 ins., 16 ins. and 32 ins. to the mile. The cadastral work was very elaborate. Captain Wheeler, in his report on Government surveys, stated that in the survey of the town and island of Bombay, about 22 sq. miles, the fields and open country were surveyed and plotted to a scale of 1 in. to 100 ft., with the native town and fort to a scale of 1 in. to 40 ft. The relief was shown by 10-ft. contours. The average cost was $7 040 per square mile.

A topographical survey, pure and simple to a scale of 1 to 15 000 (or 4 ins. to the mile) with 20-ft. contours in rough country, using Geological Survey methods, would cost, including triangulation, about $83 per square mile. To set many monuments, about 50% should be added for cost of locating them, making a total of, say, $125 per square mile. For a map of 500 ft. to an inch, with plane table, a probable good average cost would be about $150 per square mile.

In summing up, allow us to quote what is said concerning the plane table by Mr. Henry Gannett, Chief Geographer of the United States Geological Survey, and, also, of the census of 1890, and the one to be taken this year. He says: "Much misapprehension exists, especially in this country, regarding the character and application of this instrument. This arises, apparently, from the fact that it is little known. For making a map the plane table is a universal instrument. It is applicable to all kinds of country, to all methods of work, and to all scales. For making a map it is the most simple, direct and economic instrument; its use renders possible the making of the map directly from the country as copy, and renders unnecessary the making of elaborate notes, sketches, photographs, etc., which is not only more expensive, but produces inferior results."

We are going to have abundant opportunity to use the plane table, with all of our new possessions to be developed. No great work can be started until we have a good topographical map of the country to be opened.

If the author has been able to interest anyone here sufficiently to cause him to study the plane table carefully, and endeavor to use it to advantage in his work, he will feel well repaid for the time spent in preparing this brief talk.

For most of the slides used to illustrate the foregoing, the author is indebted to Mr. Newell, and Mr. Pressey, of the United States Geological Survey, through whose kindness they were obtained.

DISCUSSION.

Mr. W. M. Meserole.—I would like to say a few words with regard to plane table work. Mr. Meserole.

One of the subjects spoken of by the speaker this evening was the work in Puerto Rico, the survey of the military roads, and the surveys and improvements to be made there by the Government.

In 1896 I had some correspondence with Mr. Jeffries, at that time a member of the United States Engineer Battalion stationed at Willets Point, L. I., who had devised an apparatus for surveying which was to some extent a modification of the plane table, in which the tripod was replaced by a bicycle, the purpose of this particular device being the surveying and profiling of roads.

His plane table was a board mounted on the handle bar of the bicycle, with rollers so that a long strip of paper could be used, and furnished with a simple alidade attachment, arranged for plotting a traverse of the road, the bicycle acting as an odometer for measuring distances.

On his frame he had a U-tube partly filled with mercury, on the two columns of which floated bulbs which were attached to an oscillating beam. The beam was arranged so as to automatically record changes of grade on a strip of paper which is moved along by the travel of the bicycle, producing a profile.

When this correspondence was under way, the instrument was in the experimental stage, but when shortly after the United States troops occupied Puerto Rico, the Government began road construction in that island. I saw an account that complete instruments made on the lines of Mr. Jeffries' apparatus had been shipped to Puerto Rico and would be used in the new work there which Mr. Pollock has referred to.

The map that he sent me of the country around the Willets Point station was a very creditable map, and he claims that it was made entirely from surveys made with this instrument of his.

Now, as to the topographical surveys that have been executed by the Government, and that remain to be executed by the Government, I would like to say a few words.

Mr. Pollock has said that it is absolutely necessary before any work will be done in our new possessions that we should have good topographical maps of these countries. I agree with him exactly; but I also think it is a howling shame that here in this civilized country of ours, where we have so many great things done and to be done, we have such poor maps for us to base our work on.

The New England States—Massachusetts, Connecticut and Rhode Island—have been entirely covered by the topographical survey of the

Mr. Meserole. United States Geological Survey, executed under the system by which the United States Government pays half the expense, and the State Government pays the other half, the United States Government furnishing the necessary men to do the work.

Some of the other States have, to some extent, carried out that same method. In New York State I think we have about one-tenth of our great State mapped in that way, and we have only such portions mapped as were partially covered beforehand, so that they went into a country where, by reason of some previous surveys, they were able to spread their money over as large a tract as possible.

We have very good maps of the Adirondack regions, some in the Catskills, some along the line of the Mohawk River, and almost the entire belt of country lying between the Hudson River and the Connecticut and Massachusetts State line. Outside of that the State of New York has absolutely no maps that are of any value whatever for the basing of engineering work.

For some years past the State of New York has been appropriating the enormous sum of $5 000 a year to pay their share of the work, and I presume it is mostly used up in writing paper and postage. They get out perhaps three or four sheets a year, and part of the money is expended in reprints of sheets of editions exhausted years ago.

Mr. Vermeule was chief of the topographical survey of the State of New Jersey, which was the first State to execute a perfect map of its territory. That map was executed by the Geological Survey of the State of New Jersey, under their State Geologist, Dr. Cook, and the work was entirely in the hands of Mr. Vermeule. He has made some statements as to the low price at which that work was done. I happen to know some of his methods, and it seems to me that if he had made use of the plane table he could probably have saved a great deal of money, and certainly a great deal of labor.

In the summer of 1881 I met a man down in New Jersey coming along the road with a wheelbarrow. On the wheelbarrow he had a box, and every once in awhile he would open the box and read something that looked like a gas meter. Then, setting up a red stick, he used an ordinary pocket-compass. He would go ahead at every turn of the road, turn his pocket-compass so that he could look up the road and look back again and take a reading both ways. He would then read his gas meter, put it down and go ahead.

One night I stopped in the same hotel with that fellow and found him and another man sitting up until two o'clock in the morning plotting up their notes. If he had had that simple compass sight for an alidade he would have gotten his map as fast as he could walk over the country, and there wouldn't have been any sitting up at night to plot the work.

Mr. C. D. Pollock.—I would like to say, in defence of our State of New York, I believe that it has made a very good triangulation survey of its territory by a State survey. It was done, I believe, under the United States Geological Survey's supervision, but half the expense was borne by the State. Mr. Pollock.

Now, there is a large report on this in our library, and, judging from the size of the report, it covered the State pretty well in the triangulation at least.

Mr. W. M. Meserole.—I might speak again on that subject. Mr. Meserole.

In the seventies there was an institution in New York known as the State Survey. It was under the supervision of a gentleman named Gardiner, who was a man very high in the profession, I understand. He did a great deal of very accurate primary triangulation. It was mostly in the center of the State of New York, and covered a part of the mountain country, the Adirondacks and the Catskills, and that is the reason why the work that we have from the Topographical Bureau of the Geological Survey is on those same lines. They made use of his triangulation, and in their reports on the work done by them they stated that the work he did was of the very highest order; but he did not cover a very large section of the State, nor did he get any results that are of value for the common people, or for the work of engineering. He devoted himself entirely to the fixing of the geodetic position of certain prominent points, which, of course, are the basis for a good map, but as they are they are of no use to the public.

It was necessary for the Geological Survey to come in and complete the work, and there is yet a very large portion of the State to be covered.

Now, when we consider that there is a great area of the State that is going to be developed in some way in the early future for the benefit of the people who live here, and who are to live in the regions that we are speaking of, it does seem that it would be a very small thing for the State Government to go ahead and make a proper survey by which engineers could have a fair way of determining what they were setting out to do.

When the East Jersey Water Company was formed to utilize the water-sheds of the State for the supply of water for the cities of northern New Jersey, Mr. Vermeule, who has been already referred to as having had charge of the topographical survey of that State, was employed to make estimates of the probable supply of water to be obtained and the cost of the structures for securing it from the various water-sheds under consideration. He has published a comparison of the expenses of the preliminary surveys with what they would have been if there had been no State Survey of New Jersey to base their work on, and it takes no effort on the part of an engineer to know that an accurate topographical map of 1 in. to the mile, with contours at

Mr. Meserole. 10-ft. and 20-ft. intervals, can be of wonderful assistance to a man in locating a pipe line or a canal, or a railroad, or in determining the kind of country.

I know cases in New York State where it has taken a survey party a whole season to determine the area of the water-shed of one of the small lakes. They did nothing but traverse the ridge which formed the water-shed around that section. If there had been a topographical survey made of that section, they could have determined any particular point in five minutes from the scale.

Mr. Ford. Mr. William G. Ford.—I would like to speak of what Mr. Pollock has said regarding the advantages of the plane table. I think it can be safely stated that the cost of making a topographical survey by plane table methods need not exceed one-third of the cost of the work if performed by the ordinary methods of theodolite and tape.

Another advantage is that, as you go along, if you make an error you are liable to find it out. If, on the other hand, you rely on notes, the error may creep in, and you will not have an opportunity of finding your mistake.

As to the accuracy of graphic work, I think that there is no question, and in which connection I would like to say that I laid out for the State of New York the lands under water between Perth Amboy and the eastern end of Long Island Sound. After the triangulation was completed, the other work was done graphically.

Where it was on a large scale I felt perfectly justified in making a standing offer, that if any man who had had his oyster plot surveyed, and staked would cut the stakes off several feet below the surface of the water, I would guarantee to go and find them again, placing a boat so that a lead line dropped from it would fall in their midst.

I think it is pretty safe to say that the plane table survey can be made as close as you can possibly plot it.

The Author. The Author.—A good many people have this idea that a plane table survey is not accurate. On a small scale map you do not need to bother with plumbing to get the point on the plane table sheet vertically over the point on the ground, as a small error does not show. That is, where it takes about 50 ft. on the ground to make $\frac{1}{100}$ of an inch on the sheet, which would be in the case in the Geological Survey's work, we may neglect a few inches in setting up the plane table.

On our United States Lighthouse Establishment Survey, where we used the large scale of 1 : 500, or 1 in. to about 40 ft. we were always careful to plumb, and get within an inch or two of the point, because here an error of 6 ins. on the ground would be noticeable on the map.

The President. The President.—A few weeks ago I found out what they are doing in Massachusetts in the way of survey, in the line of the work Mr.

Meserole has spoken of which is being done in this country. I have a friend there who is a professor in the Institute of Technology, in Boston, and he is on a State Commission, which is making a survey of every town in the State, the expense of which is paid entirely by the State. The President.

They are making a map (the scale of which I have forgotten) of the boundary line of every town, and after that is made they send it to the town, and there it is put on record and serves as a standard, and as a basis for every surveyor in the town to work from.

They have completed quite a number of towns now, but they intend to map the whole State in that way.

BROOKLYN ENGINEERS' CLUB.*

No. 23.

SOME EXPERIMENTS ON THE BACTERIAL PURIFICATION OF SEWAGE.

By A. J. Provost, Jr., Mem. B. E. C.

Presented January 11th, 1900.

It is not my intention to take up very much more of your time this evening, but rather to state briefly the results of some original investigations and experiments made by the author in 1898 upon the practical success with which crude sewage is capable of being purified at high rates by means of contact beds of coke breeze along the lines of a process in actual use in England and described in a paper read before this Club by Mr. Crane in 1898.

The apparatus used was, perhaps, the smallest ever employed in such experiments. It consisted of an ordinary Welsbach gas burner chimney, 1⅝ ins. diameter by 7 ins. high. One end of the chimney was closed by a tight fitting cork, through which projected a short piece of glass tubing, which in turn was closed at will by a small cork. The apparatus was filled to the top with fine coke breeze, all of which would pass a ½-in. ring and some a ⅛-in. ring. When dry 400 c. c. of the coke took 210 c. c. of water to fill the voids, and of this 170 c. c. could be drained off readily, showing an air space in the coke of 42½% of the total capacity of the apparatus.

The object in selecting so small an apparatus was chiefly for con-

* This Club is not responsible, as a body, for the facts and opinions advanced in this publication.

venience. It also made possible the examination of the entire filtrate from a given sewage which was considered highly desirable.

During the tests which lasted for several weeks, March 11th to May 10th, crude sewage from three typical locations in Brooklyn was alternately treated. The samples and conditions were as follows:

(a) From Homewood Sewage Well.—This well received the crude sewage and house wastes from about 50 dwellings located very close to the well. No ground water; sewage concentrated and not finely divided.

(b) From Outlet Sewer foot of Flatbush Avenue.—Sewage unusually clear and dilute, due to large percentage of ground water; organic matter very finely divided, due to sewage running with gentle velocity for at least 3 miles between last house connection and point of sampling. A sample of this sewage showed only 11¼ grains suspended matter per gallon.

(c) From Twenty-sixth Ward Outlet Sewer, just above Purification Works.—Similar to No. 2, but more concentrated. Taken for comparison with results by chemical purification on same sewage.

The methods used in the test included a short incubation process, lasting for a few days prior to May 11th, which was intended to get the nitrifying organisms somewhat started before applying crude sewage. For this purpose a weak urine solution was passed through the filter or contact bed several times. It is now believed that this failed of its purpose, since the solution has been previously subjected to anærobic action, which action, without subsequent aeration, is now known to be inimical to nitrification.

Beginning with March 11th, crude sewage was introduced as follows:

The apparatus was filled to the surface with a sample which remained in contact with the coke for a period of two (2) hours. The liquid was then somewhat rapidly run off through the tube at the bottom and examined. The filter was allowed two (2) hours to aerate with bottom tube open, then filled with the effluent from first treatment, which also remained two (2) hours in contact with the coke. The filter remained at rest over night before receiving another dose of crude sewage.

All examinations made were purely physical and included transparency and odor tests, upon drawing the effluent and daily for a

number of weeks, upon the entire sample which was kept in a closed bottle freely exposed to a strong light. Such tests, it was thought, fulfilled all practical requirements. If a filtrate exhibited a putrid odor, or if such developed upon standing for a few days, no chemical analysis was needed to prove the result unsatisfactory; on the other hand, if the filtrate was bright, clear and odorless, and remained so for several weeks in a constant temperature of about 70° Fahr., no chemical analysis showing the diminution of organic matter and the production of nitrates would be particularly valuable for cases of ordinary disposal. In the case of a plant in actual and constant operation, daily, or, at most, weekly, chemical analyses of the sewage and effluent would be particularly valuable in showing the condition of the filter at any time and give warning of an approaching unsatisfactory condition. This warning, if heeded, would require but a few days' rest, or modified treatment, to restore the filter to its normal and proper state; whereas, if unknown until a putrid effluent was produced, the interior conditions of bilious state might be so extended as to throw the plant out of use for several weeks.

The term "bilious state" is used advisedly. By comparing the action of the contact bed to the digestive process of the human stomach, its capability for reducing dead organic matter may be more clearly understood. When not overfed and when supplied with the oxidizing properties of plenty of fresh air, the apparatus performs its functions in a satisfactory manner, alkaline reactions being then normal to the sewage, to the contact material and to the discharges. When overworked or insufficiently supplied with oxygen, acid conditions prevail, putrid gases are produced and will continue until diet is prescribed. The analogy may be further continued by comparing the action of the septic or liquefying tank to the process of mastication.

While, as stated, no chemical analyses were employed for determining the amount of nitrogen converted into nitrates, it is believed that the relative amount of purification and transformation to nitrates was shown to some extent by the amount and rapidity with which green algæ growths appeared in the effluents; most of the later tests showing some surprisingly beautiful specimens of this plant life, one such sample retaining all its apparent vigor after being excluded from the light for at least 4 months.

In the statement of results, with the different samples of sewage

used, the charge of crude sewage will be designated as treatment 1, and the charge of its filtrate as treatment 2.

March 11; treatment 1, Sample "*A*" (Homewood sewage) from top of well which contained about one day's supply of sewage; filtrate turbid; when placed in an 8-oz. white bottle, was sufficiently transparent to show large black letter *C*, $\frac{3}{4}$ in. in height, held 7 ins. from the bottle; contained considerable finely divided organic matter in suspension.

Treatment 2; effluent much improved; letter *C* was now visible at a distance of 12 ins. Kept in corked bottle developed odor in a few days which lasted for about 6 weeks. A flocculent dark brown precipitate appeared within a few days, which remained constant in color and amount for fully 8 weeks.

March 12th; following day, Sample "*A*," treatments 1 and 2. In both cases a decided improvement was noticeable. There was still a slight turbidity and cloudiness due to finely divided suspended matter. An odor developed in effluent within a few days which remained for 30 days. A flocculent precipitate appeared similar to that in effluent of preceding day except that it was much lighter in color and less in amount. No chlorofilic algæ growths ever appeared in the effluents of March 11th and 12th.

March 18th; the filter was allowed to rest until this date in order that the nitrifying bacteria might become more fully established. On this date treatments were made with Sample "*C*" (26th Ward sewage). This sample was much less concentrated than Homewood sample, owing to presence of considerable ground water; the matter in suspension was also more finely divided owing to length of flow before reaching sampling point. Filtrate 1, slightly cloudy. Filtrate 2, clear and entirely odorless.

March 19th; Sample "*C*"; Filtrate 1, clear.

Filtrate 2 resembled Ridgewood water and was absolutely free from odor; nor was any change noted during a period of about 6 weeks. This also applies to results from samples taken from same source treated March 21st, 25th, 26th and 28th. In all these cases, filtrates 2 developed, after standing in closed bottles, exposed to strong light for from 2 to 3 three weeks, abundant growths of green algæ. These rose as columns in the center of the liquid, or attached themselves to the sides of the bottle. They were of the most delicate structures, and

many of them quite beautiful. These growths were quite absent in the filtrates from the Homewood sewage, but the effluent of one such sample taken on March 22d slowly acquired such a growth.

During the tests it was noticed that the effluents from the Homewood sewage, from samples taken on Mondays, showed a much greater turbidity than other effluents, although little suspended matter could be detected, nor was there any odor. The turbidity resembled smoke in the effluent, and, it was suspected, was due to excess of soap in the sewage. After several confirmatory trials, it was determined to see what effect known soap would have on the filtrates. Accordingly, clear water was charged into the filter, and, after standing 2 hours, removed, when it appeared as clear and odorless as before charging. A solution of soap suds, mixed by hand in a basin until the water was decidedly turbid (about the color of smoke), was introduced and left in the filter for 2 hours. A sample of the same soap suds was placed in a bottle for comparison.

The filtrate discharged was not only noticeably darker in color and more opaque than the charge, but it also had a disagreeable odor. Upon being placed in a closed bottle, the contained solids separated some and settled to the bottom, the odor increasing with time until it became almost unbearable. Clear water was then run through and came out turbid and slightly offensive. Repeated washings did not appear to remove much of the soap intercepted, and finally the filtering material was removed and the soap adhering to the glass washed away. The coke, however, seemed to be much injured, since for the following week no successful effluents were obtained from the sewage treated. Since some of the deterioration might have been due to algæ growth in the body of the filter, it was decided to cover the sides and top of same, until this time freely exposed to the light, with opaque paper. The apparatus was then allowed to rest for some weeks.

On April 30th Sample "*C*" (Twenty-ninth Ward sewage) was given treatments 1 and 2, which was repeated on May 2d. In both cases the effluents were clear, colorless and without odor. On May 3d, treatment I alone gave an effluent as good as any previously obtained with two treatments. No deterioration appeared later in any of these when kept in either open or closed bottles, and green algæ growths began to appear about the third day after treatment.

On May 7th the upper layers of the filter to a depth of 3 ins. were

removed and found to be entirely sweet and the coke apparently as clean as it ever was.

These tests showed the filter to have regained its former efficiency.

The deductions to be drawn from the experiments appear to be that under proper conditions it is entirely practical to purify crude sewage at very high rates. (Equivalent in the experiments with two changes per day to 260 000 gals. per acre per foot depth of contact material.) The best results will be obtained with sewage which has been somewhat disintegrated by a long flow before treatment takes place, or with what may be termed stale sewage. The presence of soaps or fats in large quantities is to be avoided, and the trouble to be expected from soap will be directly proportional to the amount thereof, and inversely proportional to the time it has been in the sewage before treatment takes place. Excessive soap, however, should not be regarded as prohibiting the use of bacterial treatment since it is readily eliminated by the use of a suitable small amount of lime.

Assuming that the contact beds are 4 ft. in depth, with air space of contained material equal to 40%, it is possible with two fillings in 24 hours to treat upwards of 1 000 000 galls. of sewage per acre per day. Such treatment allows 5 hours for filling, 6 hours for standing in contact with the nitrifying organisms, and 13 hours for emptying and aerating. The only limit to the depth of the contact material is that to which air may be freely drawn upon emptying and during the aeration period.

Since the depth of the beds also represents the amount of head lost in the treatment, it will, in many cases, be limited by the available head which will allow the effluent to be disposed of without pumping.

Very recently, beds 13 ft. in depth have been experimented with at the Crossness outlet of the London Sewage System by Dr. Frank Clowes, Chief Chemist to the London County Council, with results apparently as successful as with the beds of 4 ft. depth which have been in operation for several years. This will mean that crude sewage may be purified at the enormous rate of 3 400 000 galls. per acre per day.

With primary beds or single treatment Dr. Clowes' experiments show a reduction of all the suspended and 51.3% of dissolved putrescible oxidizable organic matter and an effluent free from odor. With

the addition of a secondary bed of finer material, the organic matter in solution was reduced 69.2%, giving an effluent in which gold fish, roach, dace and perch have lived for months in perfect health.

Two years ago an eminent English scientist, Joseph Priestly, made the following statement:

"The future of bacterial sewage purification is assured, and sanitarians will look forward with anxiety and impatience to reports and other information on the subject; the year 1897 having simply seen the principle well established."

These statements have since been verified in the success of the process wherever tried, and in the wide-spread interest shown in its development by scientists and municipal authorities.

The writer desires to express his indebtedness to Mr. A. S. Crane for his valuable assistance in connection with the foregoing experiments.

DISCUSSION.

George C. Whipple.—The experiments described by the author, though confessedly simple and incomplete, correspond in some of their results with some of the more carefully conducted tests. Mr. Whipple.

During the past year many experiments have been carried on in connection with the septic system of sewage disposal, and this process is emerging from the trial stage to the practical stage. At first received with some scepticism, its main principles are now well established. Not only have we the testimony of trustworthy English experts, we have lately had given to us through the last report of the Massachusetts State Board of Health an account of experiments made by Mr. H. W. Clark, Chemist to the Board, at the Lawrence Experiment Station. These analyses enable us to compare the results obtained by the septic system with those obtained by the sand filter beds that have been in operation there for many years. I quote some of these results as an example of what can be done by the septic system.

Average Analyses, During 1898. In Parts per Million.

Samples Analyzed.	Free ammonia.	Albuminoid ammonia.			Oxygen consumed.	Bacteria per c.c.
		Total.	In solution.	In suspension.		
Regular sewage at the experiment station.....	29.9	5.8	2.9	2.9	32.2	1 862 000
Sewage as it entered septic tank................	44.4	7.9	4.7	3.2	40.0	....
Sewage as it left the septic tank (septic sewage)	48.6	4.1	3.2	0.9	22.9	324 500
Effluent where septic sewage was filtered through sand. Rate, 130 000 galls. per acre daily........	14.0	1.0	....	....	7.6	88 000
Effluent where septic sewage was filtered in the "bacterial filter." Rate, 805 000 galls. per acre daily........	17.4	1.0	....	....	6.2	44 100
Effluent of sand filter No. 1. Rate, 60 500 galls. per acre daily........	3.8	0.6	....	....	5.0	15 800
Effluent of sand filter No. 2. Rate, 38 300 galls. per acre daily........	1.7	0.2	....	....	2.0	51
Effluent of sand filter No. 4. Rate, 19 300 galls. per acre daily........	0.4	0.1	....	....	1.0	9

For details of the different processes the speaker will refer to the report quoted, but the figures given show that the septic system is one of great promise. With sewage being filtered at the rate of 805 000 galls. per acre daily, 97.7% of the bacteria were removed and 87.3% of the albuminoid ammonia, while with sewage being filtered through sand at the rate of 60 500 galls. per acre daily, the removal of bacteria was 99.15% and of albuminoid ammonia 89 per cent.

Mr. Whipple. It is certain, however, that we do not yet know how to properly design a septic system. It was at first thought necessary to cover the septic tank with an air-tight roof, but it has been found possible to do away with the roof, as practically the same changes take place in a deep tank exposed to the light, the thick scum that arises forming a screen of sufficient density. The speaker has been especially interested in this development, inasmuch as he suggested in the discussion of Mr. Crane's paper, given before this Club some time ago, that the chief function of the roof was to exclude the light and thus further bacterial development. At Lawrence it has been found possible to reduce the size of the septic tanks, as the sewage reaches the station in a partially septic condition. The size of the tank and the rate of flow through it will depend largely upon whether the sewage to be treated is fresh or stale. There are many points about the process that need to be better understood before we can adopt it on a large scale, and much experimental work needs to be done in this country. The author of the paper this evening, even though he has confined himself to a small field, has set us an example in this matter.

BROOKLYN ENGINEERS' CLUB.*

No. 24.

LANDSCAPE ENGINEERING.

By Robert James Beach, Mem. B. E. C.

Presented February 8th, 1900.

In presenting to the Brooklyn Engineers' Club to-night a short paper on Landscape Engineering, the object is to awaken an interest in this neglected branch of our profession by glancing at the subject in a general way. A dozen continuous talks might be given without exhausting the theme, which includes many subjects, any one of which could be easily made to cover the time allotted to me to-night.

This field, properly belonging to us as engineers, has been to a great extent abandoned to architects and gardeners, so that at the present time it is called "landscape gardening" or "landscape architecture" by most authors, and but few engineers give it any thought, much less study.

As the treatment of any piece of landscape work usually includes one or more buildings, the architect has his field in their design. Horticulture or methods of producing certain plant and tree effects can best be left to the gardener. The engineer's work is in the locating of the buildings which the architect plans, and the general treatment of the grounds which the gardener is to beautify under his directions. In other words, the engineer is to take the ground as Nature presents it and bring it into harmony with the work of the architect and gardener.

* This Club is not responsible, as a body, for the facts and opinions advanced in this publication.

Therefore, as the usual modern building does not often resemble anything in Nature, either natural features of the landscape must to a certain extent be formalized to accord with the building, or the appearance of the building changed by the introduction of elements existing in the natural surroundings, thus bringing harmony and beauty where the engineer and architect work together. An example of this is shown in Fig. 1 and Fig. 2.

Landscape engineering is the artistic branch of our profession, and whereas, in all other branches, we are pioneers, in this one we follow civilization and improvement. There is no country offering a richer field in this branch than ours, and probably no city offers such opportunities through its great wealth and great variety of natural beauties as New York and its environs. The Hudson with its Palisades and Highlands; Long Island, with its beautiful salt water frontage and rich soil; Westchester County, with its frontage on the Sound, its rocky ledges and picturesque diversity of hill and dale—these present a field for the landscape engineer, as yet but little encroached upon.

Suburban villas and country seats are becoming the favored homes of our rich classes, and they are planned by members of our brother profession who stand in the front rank as regards architecture and interior decoration. A taste for rural improvement is developing rapidly, and good suburban streets, together with beautiful homes, are evidences of this increased taste and growing wealth.

But in the improvement of private grounds, through neglect on our part to take advantage of the situation, the average owner of a suburban home turns himself into an amateur engineer, and with no practical knowledge, and the aid of the gardener, proceeds to waste time and money in efforts the incongruity of which are almost pitiable.

Locating the House.

Grounds on which the buildings have already been built offer but a limited field for the talents of the Landscape Engineer. His most important work is in the locating of the house. The average wealthy resident of New York who wishes a fine country residence usually gets it in the following manner:

First.—He looks around until he finds a place, perhaps several acres in size, which takes his fancy. Perhaps he has it surveyed if the previous owner has no reliable map. He then drives over it with his

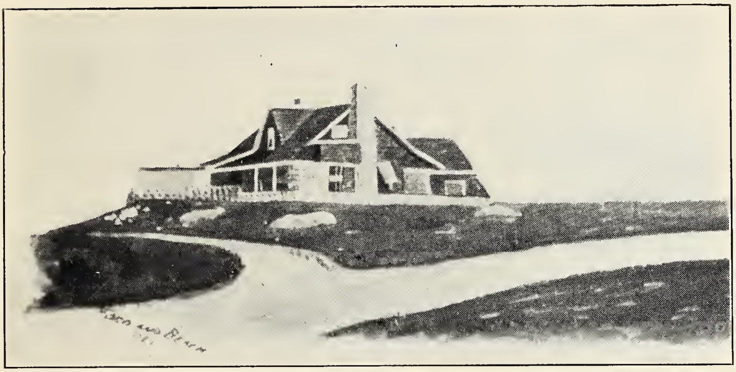


FIG. 1.—HOUSE BUILT ON ROCKY BLUFF. NO TREES.

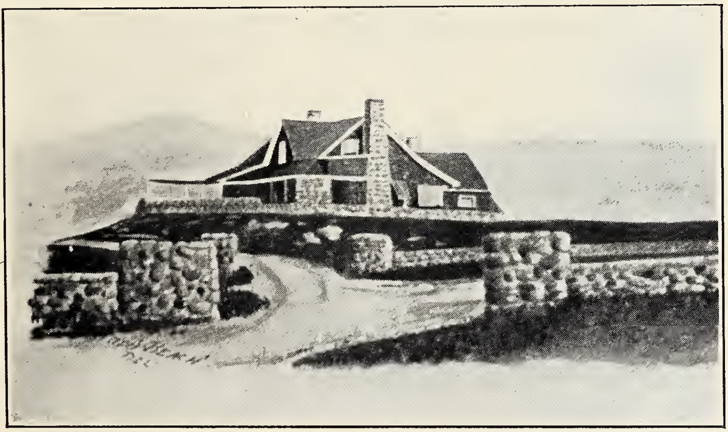


FIG. 2.—GROUNDS AND HOUSE BROUGHT INTO HARMONY BY INTRODUCTION OF STONE WALLS SIMILAR IN CONSTRUCTION TO STONEWORK OF HOUSE.

wife, and together they select a site for their future home. Then he employs an architect to whom he gives his ideas for a house. The architect prepares the plan, often without seeing the grounds. An engineer is called upon to stake out the corners of the building, and perhaps to stake out some roads and paths located by the owner. The rest is left to the gardener, usually with the painful results above mentioned.

Now, let us suppose that after buying his land, he called in a landscape engineer. Recognizing the many weighty considerations which enter into the selecting of a site, and that a false step taken in this respect cannot be afterwards retraced, the engineer will locate the home after considering the following points in order:

a. Healthfulness.
b. Convenience.
c. Outlook.
d. Good water.
e. Soil.
f. Natural features.

In arriving at his conclusions, and in connection with the work to be afterwards accomplished, the engineer will always save time and expense, when the grounds are not nearly level, by preparing a topographical map. Such a map shows prominent natural features, and on it buildings and roads are located with ease, and usually to the satisfaction of the owner. Of course, the owner must be pleased, and he usually has ideas of what he wants which are at variance with those of the engineer. Often a compromise must be made, but the engineer will always bear in mind that he will be judged by the completed work as though it were all his.

Healthfulness.—In this connection, the engineer will have the house located on dry or high ground, avoiding swampy ground which cannot be drained or made healthful by some plan which his ingenuity may suggest. Plenty of sunlight and moving air with good drainage are necessary. A site on the bank of a broad river or large lake is generally healthful and sometimes milder in winter and cooler in summer, than one on a hill further back from such water.

Convenience.—In locating on a hill, consider convenience of access. If necessary make the approach wind to a considerable length in order to get a grade no steeper than 5 per cent.

Outlook.—The suburban resident will sacrifice many other good points in order to secure a good view. Often fine trees must be cut down in order to secure vistas, and many owners will not consider convenience of access if the question of a fine view is involved.

Good Water.—Before deciding on a house site, see that an uncontaminated water supply is assured. No one but an engineer is apt to realize conditions which lead to disease and death. Wherever possible, we believe in planning for a reservoir with a pipe service to the house, rather than take chances with a well and house tank, no matter how pure the well water may seem to be.

Soil.—The foundation of the building must next be considered. A rock foundation according to Scripture is the best, but in those days Portland cement was doubtless an unknown quantity. Rock excavation is expensive, and often it is almost impossible to keep dry a cellar dug in rock. For general purposes, rock is to be avoided for foundation purposes where excavation is necessary.

Natural Features.—The beauty and variety shown in the grounds must depend principally on the natural features properly brought into harmony with the buildings. Figs. 1 and 2 show how effective banks and rocks become when properly handled. Fig. 3 shows how a stream can be crossed in an artistic manner. Uneven sites must be handled with skill in adapting the house to the grounds, but it is by such adaptation, happily executed, that the difference between architects and engineers of taste and culture and the mere routine workers is brought out.

Style in Landscape Architecture.

Having decided on the location, work in connection with the architect may begin. As before stated, the grounds must be brought to accord with the house, or the house designed to accord with the grounds. Walks and features of the ground are designed to meet doors, windows and architectural features of the house. Consequently, if the house is of formal style, the grounds immediately around it must be formal; on the other hand, if the house is surrounded by native woods, it should be built of natural field stone or logs with the bark on, to be in harmony.

But two general styles in Landscape architecture are recognized:

1. The Ancient or Geometric, also called the Formal.
2. The Modern or Natural.

Fig. 3.—Artistic Method of Bridging a Stream in a Durable Manner.

Fig. 4.—House and Grounds not in Harmony. Modern House Surrounded by Simplicity of Nature Presents Incongruous Effect.

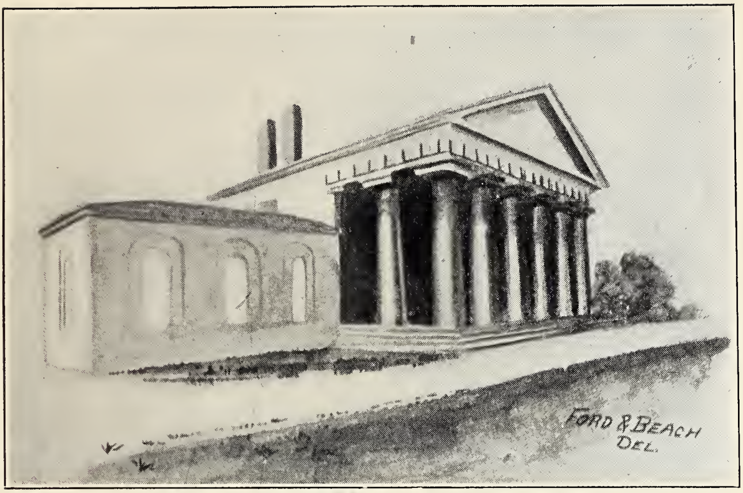


Fig. 5.—Villa Surrounded by Smooth Lawn.

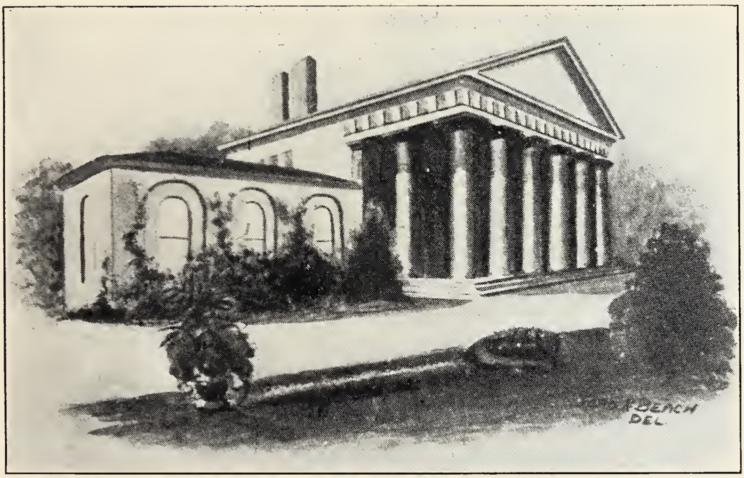


Fig. 6.—Villa and Grounds Brought into Harmony by Introduction of Shrubbery.

Geometric Gardening.

In this class are the so-called Italian and Dutch Schools.

a. The Italians introduced stone terraces, balustrades, steps, geometrical flower gardens, statues, vases and sculptured ornaments.

b. The Dutch introduced straight avenues, long basins of water and canals and vegetable sculpture, so called.

c. The English and French took their ideas in formal gardening from the Italians and Dutch, and the English introduced the

Modern or Natural Style.

In this style, the grounds are laid out to represent Nature as fully as possible. It is in most general use in our country, for, independently of taste, it is comparatively inexpensive.

In England, where expense need not be so much considered, there is a fierce rivalry between the partisans of the Geometric and the Natural systems.

It seems to me that each has its proper field. The large formal building has its dignity and beauty enhanced by being set in well-arranged formal surroundings, for, as we have shown above, the sudden transition from a fine mansion to the simplicity of Nature would not be in good taste, as shown in Fig. 4.

Figs. 5 and 6 further illustrate the importance of this.

Fig. 5 represents a beautiful villa, complete in itself, placed on a smooth lawn, such as we usually see surrounding houses in our locality. The house, being a highly artistic object, presents to us a certain incongruity to the surrounding grounds. Let us add to the grounds some features in keeping with the house, and an increased richness of effect will be noticed, as in Fig. 6.

I have prepared a number of plates which illustrate some of the points I have tried to bring out this evening.

They illustrate the idea that the house and grounds must make one complete whole, that no country seat can ever be planned to give highly satisfactory results unless road entrance, (Fig. 7), approaches, (Fig. 8), and trees and slopes are so planned as to form integral parts of a conception beautiful in proportions and finish.

We will repeat, in closing this brief paper, that the feeling which

prompted its preparation was the desire to arouse an increased interest in this artistic but neglected branch of our profession.

Before closing, I will present some views of Japanese landscape art, considered by many as superior to any other. During a sojourn in Japan some years ago, I was greatly impressed by the work done by this artistic people in what may be called the Japanese Natural School. [These illustrations, although excellent, it was not expedient to reproduce.—Ed.]

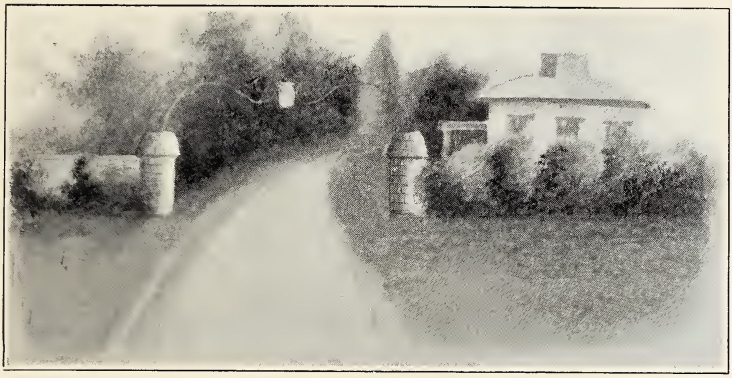


Fig. 7.—Road Entrance.

Fig. 8.—Approach to House through Grounds.

DISCUSSION.

VICE-PRESIDENT.—Gentlemen: We have all been very much interested in what Mr. Beach has had to say. It has been a revelation to many of us. Are there any members who can contribute further? I think Mr. Ford must have something to tell us of the Japanese work. Vice-President.

MR. FORD.—Beauty in landscape work, I think, is carried to a far greater extent in Japan than I have ever seen it elsewhere. No matter how poor a man is, no matter how small a piece of ground he owns, he does something to beautify it. There is scarcely a square foot of ground within the reach of a man living there that is not improved. One stretch, for instance, of scenery on the Inland Sea, of about 200 or 300 miles, is surrounded by hills and dotted with islands, so that in passing through you would think, not following the chart, that you were going to run into something. Mr. Ford.

The islands are very attractive, beautifully terraced, and there are miles and miles of enchanting scenery. I think any one going there is impressed with that as much as with the inhabitants. It is simply beyond description.

VICE-PRESIDENT.—Is there much development in Japan, as far as the railroads and machinery are concerned? Vice-President.

MR. FORD.—Yes, there is very rapid development. I think it is only about 50 years since Japan was opened to the world, and at the time I was there they were building their own steamships. They had large dry docks, as large as those in this country, if not larger. They were building their own railroads. They had electric appliances, a good post-office system, and they were developing mechanical arts rapidly. Mr. Ford.

VICE-PRESIDENT.—How about their pavements and municipal work generally? Vice-President.

MR. FORD.—Their municipal improvements are rather crude. Their streets are generally good, the traffic upon them being light. Up to very recent times there was no necessity for having improvements in that line. As far as their sewage arrangements are concerned, they are behind the times, but they are rapidly improving. Mr. Ford.

The Emperor, to my mind, is one of the most wonderful men I have ever heard of, having of his own free will renounced despotism to give the people a constitutional form of government. They have sent some of their brightest young men to European and American cities, and have discussed the different features of those improvements already adopted, and culled out the bad features.

They have sent representatives to study the work of the United States Departments, also to England, Germany and other countries.

Mr. Ford. They have taken the best as a standard, and added to it the specialties of other nations.

Mr. Meserole. Mr. Meserole.—I think that one of the best illustrations we have of the difference between the way they do things in China and Japan is brought out by some of the facts Mr. Ford is speaking of. Some 20 years ago a large number of students were sent over from both Japan and China to America and Europe to study. All the Eastern colleges and the larger schools received a quota of each, and I came in contact with a great number of them. The young men from Japan stood very high in their classes. Indeed, some of them were at the very top of their classes in our best colleges, and were, in general, excellent young men. The Chinamen, on the other hand, were just what you would expect to be selected by a corrupt government by favoritism. The way they carried themselves was just the way that the political heelers and those who receive favors from political heelers carry themselves in this country. That is the difference between them, and the result was illustrated in the war between Japan and China.

Mr. Ford also spoke about the way they ornament the ground of the poor, and the very small grounds in Japan. I was at a meeting a short time ago where the subject of discussion was the way in which the tenement sections have been beautified in some towns in this country where some of the large industrial corporations have tried to better the condition of their employees. It was especially brought out in regard to the settlement in the neighborhood of the Cash Register Manufactory, at Dayton, O. There, in what was one of the slums, this factory was established, and the population became quite dense. A great many small houses were built, crowded in between other houses, land was very scarce, and the grounds around the houses were so small that they were utterly neglected —just room enough to collect rubbish, and not room enough for anybody to care about taking pains with it. The company, to bring about better surroundings for their employees, decided to offer prizes to families who would make, during 12 months, the greatest improvement in the conditions of their surroundings. I think the first prize was $10, with second and third prizes of, perhaps, $7.50 and $5, and that plan has been carried on for some 3 years. I have seen a series of photographs of the houses, with their back yards, taken at intervals of a year during the 3 years I speak of, and the change is surprising. An old shanty that may have been used to house a goat, built out of boards stolen off a neighbor's fence, has been covered with morning glories, or something of that kind, and from being an utter disgrace is now quite a landscape feature.

Now, that is landscape gardening in the small, and it has been proposed by the Society before whom this matter was brought up to try similar experiment in Brooklyn, and I think it will be done during the

coming year. They have appointed a committee to select some eligible spot, where the houses are not so close together but what the people on the street can see the benefit of the improvements. They will offer prizes to the people if they can induce them to interest themselves at all. They will furnish them with what is necessary to work with in the way of seeds, and furnish a landscape gardener who will give them advice, and they will see what results they can get on that block. Mr. Meserole.

In connection with landscape work I heard something a while ago that might be interesting. A gentleman who lived in the neighborhood of Rochester started a fine country seat, and his special ambition was to have a fine lawn. He employed an English gardener, and gave him *carte blanche* on the lawn question, and gave him everything he wanted to make a lawn with. After two or three years he took a trip to Europe, and he was especially impressed with the lawns around the great English estates. He thought he had a good lawn before he went away, but now, on his return, he was satisfied that he had nothing but an old grass field. He spoke to his gardener about the English estate in question, and the gardener said: "I know that estate well. If you want that kind of a lawn, and don't care how you get it, I'll start right in now, and guarantee to produce it." "Well," said his master, "all right, what is peculiar about it?" "Well," replied the gardener, "for a thousand years there were sheep pastures there. If you buy the sheep we'll start on your lawn right away."

Mr. Pollock.—I would like to ask the author whether he finds the plane table a great advantage in landscape gardening. In talking with Mr. Edward P. Adams he said he used the plane table almost exclusively on landscape gardening. Mr. Pollock.

The Author.—The plane table has great advantages. I find it a very great advantage. Also the kodak, which is frequently of great assistance. The Author.

A Member.—I would like to hear something about box edges, whether they are being used a great deal in landscape architecture, and whether they are considered good. A Member.

The Author.—Box treatments have been in great part done away with. The only use for box would be where we wanted to introduce a formal point to the surroundings of a house that is formal in its character—for instance, to introduce a marked straight line along a path where you wanted to conceal the path which might mar a vista or view. The Author.

A Member.—I would like to inquire how much of a field there is for landscape engineering as a profession by itself. It seems to me that the architect—the man who designs the house—should be the man that would lay out the grounds, and make everything in keeping. A Member.

The Author. The AUTHOR.—In my judgment, a landscape engineer could be utilized to advantage on almost any grounds which the owner thinks worthy of a home site. After securing a plot the landscape engineer should be employed to lay out a general plan, including locations of all the houses. When the houses are close to each other it is especially advisable to have them in harmony with each other.

In regard to the landscape field for engineers, I would say that men who make that a business, and who are prominent, have more work than they can handle.

The average man never thinks of having an engineer now-a-days, unless it is for some big place. To a great extent the architect has usurped the powers of the engineer. The engineer should be called in always before the architect is started to work. The engineer should select the site for the house, and plan the development before the architect is called in. That is the field of the landscape engineer.

A Member. A MEMBER.—When you take a large piece of property, with lakes and rivers, laying out of towns, and so on, there is a field for the engineer. But on a small piece of property, it seems as though it was rather unnecessary to employ an engineer, and that the architect ought to be the man to do the whole thing.

Vice-President. VICE-PRESIDENT.—The line of distinction between the architect and the engineer is a very delicate one.

I remember Mr. George B. Post getting up before the American Society of Civil Engineers, and telling them that the architects were the engineers of the world. I would reverse the statement, and say that the engineers are the architects of the world. An architect's work is engineering, except the artistic part. His construction of a building is structural engineering from the cellar up. It is a little architect and a great deal engineer.

The Author. The AUTHOR.—I think that unquestionably true. The architect has in many ways usurped the functions of the engineer. An architect puts up one of those big 20-story buildings in New York, and he often employs an engineer for most of the work. The engineer's name is never seen, and the architect gets most of the credit. Those big buildings are engineer's work principally. In the big firms of architects there is usually an engineer who calls himself an architect.

Mr. Meserole. MR. MESEROLE.—I know, as a matter of fact, that a great many of the big country seats in this country have been designed by landscape architects—men who made a specialty of landscape work, and were, in fact, men of the caliber of Mr. Ohmstead, the great Boston landscape designer, who were utterly precluded from advertising the fact that they were the men in charge of that work. They acted, and were bound to act by the terms of their agreements, with the architect for whom they were working, to call themselves no more than his draughts-

men in his office, although they were independent men, retained for that particular work. Mr. Meserole.

I remember a drawing made in my office for a landscape architect who was associated with me in business, to be exhibited in the Annual Exhibition of the Architectural League, covering improvements that were laid out for Mr. E. C. Benedict, at Greenwich, Conn., that were executed under the supervision of a very prominent firm of architects in New York. On his exhibition drawing he gave the name of the architects and his own as landscape architect. The designer was a landscape architect, and a member of the Architectural League, but the architects were able to force him either to remove that drawing from the wall before the Exhibition was opened, or to take his name off of it, although he had their name on it as well as his own. I might say, further, that there does not seem to be any limit in the size of grounds that the landscape architect will be called in on. This man I speak of covered sometimes a plot of ground as small as 100 x 200 ft. with a single house on it. He also covered, as Mr. Beach suggested, a number of houses lying close together on small plots. He also worked on very big plots. One, we had, for instance, covered 4 000 acres.

The Author.—Work of this kind is done perhaps more in Westchester County than it is in Brooklyn and Long Island. In doing the work we lay out a large tract, each piece to have a certain style of house, and the whole to form one large plot, the houses to be in keeping with each other, and then you get an ideal collection of homes. The Author.

Mr. Williams.—Most of those have been laid out in parks like those in the Catskills. Mr. Williams.

Most people who have small places won't go to the expense of employing a landscape engineer.

The Author.—Very often the architect will plan the house without looking to the ground at all; perhaps he will not take the trouble of having levels taken. Consequently, the natural landscape features, often beautiful, are sacrificed, and the owner, having gotten his plan, starts his excavator in blasting out all the natural features surrounding the house. The Author.

This country is just approaching the point where the field for landscape engineeeing is opening and the people need educating only. Take the average large real estate owner in New York who wants to build a suburban home. He doesn't know that there is such a thing as a landscape engineer. He goes over the ground, as I said, and selects his location, then gets his architect, and never thinks of bringing in a landscape engineer.

Mr. Strachan.—How is that arranged in England? Mr. Strachan.

The Author.—There are a great many landscape engineers there, and numerous books have been written on the subject. The Author.

Mr. Strachan. Mr. Strachan.—And advertised separately as landscape engineers?

The Author. The Author.—There are different schools of landscape engineering.

Mr. Williams. Mr. Williams.—They usually use the name of landscape architects. Most of the present landscape engineers in this country are not engineers properly. The engineer never appears at all.

Mr. Meserole. Mr. Meserole.—My experience has been that the landscape architect got the business. He knew how to handle shrubbery and trees in planting, and he hired a man to do his measurements, lay out the work, etc., and got the premium.

Mr. Williams. Mr. Williams.—The engineer is not supposed to be an artist in the artistic sense, being simply employed to measure the ground,

Mr. Strachan. Mr. Strachan.—It takes an engineer with a peculiar artistic inclination to become a good landscape engineer. I think that some engineers would be much better in that line than others. Just as some architects devote themselves to plain substantial buildings, while others have a strong artistic sense in the development of the beautiful features of the building. There is, however, a field for every man—a field for artistic work in nearly every branch of engineering.

The Author. The Author.—Now is the time. The artistic features always come last, and the architects seem to be taking advantage of the situation, to the loss of the engineers.

Mr. Tuttle. Mr. Willard S. Tuttle.—Landscape engineering is coming to the front. There is an association of this kind in Minneapolis. Perhaps there are others.

Mr. Provost. Mr. Provost.—Harvard University has recently established a course in landscape work, and from their prospectus it would appear that perhaps 90% of it was pure engineering.

The Author. The Author.—Both the architects and the artists in New York are now associating for definite purposes. The artists are taking steps to beautify New York, and using their influence to get the authorities to put up beautiful City buildings. The architects—we have a very fine class of architects in this country—are up to the times, and are going after everything in their line. The engineers are doing absolutely nothing. It is our field and we ought to take steps to regain it.

Mr. Williams. Mr. Williams.—Rows and rows of houses are built around a court in the middle of a block. The houses are decorated in front, while the rear of the houses, all around the court where the families spend most of the day, look out on the roughest kind of brick and mortar. I think a great deal could be done to beautify those back gardens.

Vice-President. Vice-President.—If board fences were abolished, and picket fences erected in their stead I think people would take more care of their yards, and pretty soon the outlook in the rear would be very pleasant. People get within a board fence, and live as they please.

The AUTHOR.—A small wire fence would be more attractive, or a low wall, if something more stable is desirable. The hedge is the most attractive of all methods for marking a division line. The Author.

Mr. MEEM.—I should think that alleyways would be very desirable, where the sewers, water and gas pipes could be put. That would certainly be the utilitarian end of it. Mr. Meem.

The AUTHOR.—I have some sketches at home, on the subject of back yards, and it is remarkable what can be done with even the smallest of them, in the way of making them beautiful. With summer houses and back porches, families can have their breakfast *al fresco* in the summer time. Apparently but little effort is ever made in the direction of back yard improvements. There is occasionally, here and there, a house where the owner has the artistic sense, and knows what he wants, but these are rare. This, in my opinion, is entirely due to lack of education on the part of the public. The Author.

A. J. PROVOST, Jr. (communicated).—The author's claim that the development of landscape features of an estate should be the work of the Engineer rather than that of the Architect seems to warrant serious consideration. Mr. Provost.

In the first place, what does the greater part of the work consist of? The usual conditions which the modern suburban estate in embryo presents to the landscape designer will include a more or less extended area of uneven ground whose contours and natural features should be carefully studied. To do this properly a more or less accurate survey of the whole property should be made. This will include a topographical map with contour lines for about every 3 to 5 ft. in elevation, the location on same of large or beautiful trees, rocks or clumps of trees which it may be desirable to save, and, in a general way, the character of the soil in various locations. The levels should be referred to the water level of the lake, stream or bay in the case of such frontage, or to the highway from which entrance is to be made if the estate is an inland one. This is surveying work and within the province of the Engineer.

With such a map, having familiarized himself thoroughly with other conditions such as prevailing winds, azimuth of best view, considering in this connection, if possible, with water frontage, the dazzling effect of the afternoon sun on the water, the Engineer is prepared to locate in the most satisfactory manner, not only the house but also the roadways, stables, water supply, house drainage disposal, terraces, vegetable and flower gardens, drying ground and locations for games of outdoor amusement.

These are practical questions involving for the most part engineering judgment or skill.

The Engineer is unquestionably best qualified to make preliminary estimates on the cost of so developing the grounds, to draw plans

Mr. Provost. and specifications for same and superintend the construction, for this is his chosen field.

If the work is to be contracted for, or in almost any case, the Engineer should have an Assistant constantly on the work who will make all measurements and give the necessary lines and levels as the work progresses.

When the Engineer's plans are complete, it seems proper that the Architect should be called in to design the buildings in harmony with the landscape plan.

In general, the estates which the Engineer is called upon to plan will be occupied as summer homes, and several things may be sacrified in the location of the house to obtain the best air and view. Thus a home for exclusively summer use may have a rate of grade on its road approaches far in excess of the figures stated by the author. There are many such approaches on the north side of Long Island as steep as 10 or even 12 per cent. Of course the figures given by the author are to be preferred, but no hesitation is shown in adopting almost any grade if demanded by the conditions.

An important item to be considered by the Engineer in distributing his cuts and fills is the quality and quantity of top soil existing along the high contours. The site selected for the house where there is a hill is pretty apt to be at or near the summit. Here in most cases the soil annually denuded of its mould has been so difficult to keep fertile that it has been abandoned for agricultural purposes or perhaps has never been used for such.

The item of top soiling a bald sandy knoll is a very expensive one, but may be much reduced. if not eliminated, by saving the existing turf where it is possible to do so. Whereever this turf is removed, topsoil should be spread to a depth of at least 6 ins. before treating with fertilizers, for no amount of manure placed on an open sandy soil will give much result.

The condition relative to grading which usually presents itself is that the high poor ground must be cut into and the rich fertile low spots covered over. Since rich soil will often be found in the valleys to a depth of 3 or 4 ft. all of this should be taken out where a fill is to be placed, and used from a borrow bank for topping the finished grades.

The success of road building, especially with steep grades, will depend largely upon carrying off surface water before sufficiently accumulated to wash and gulley. In this work the Engineer stands best qualified to obtain the desired result.

Pre-eminently his field also is the disposal of the house drainage, the source of water supply and mechanical apparatus for lifting and the storage of same.

In his treatment of the roads alone, particularly in the selection of

Mr. Provost.

surfacing material, the Engineer may be able to save his client a large percentage of the fee paid to him for his entire work by the use of a suitable local material the virtues of which are entirely unknown to to the architectural or lay mind. When the Engineer seriously enters this field of landscape development we shall expect to see gravel roads as successful as they are economical.

It appears, then, that the Engineer, and the Engineer alone, possesses the qualifications necessary for planning and carrying out landscape work. If he will master the conditions affecting the artistic element of the work, the field will be his.

The financial inducements in the specialty lie in a clientele able and willing to employ the best man for the best results.

BROOKLYN ENGINEERS' CLUB.*

No. 25.

THE ACTION OF WATER ON ASPHALTS.

By George C. Whipple and Daniel D. Jackson, Members B. E. C.

Presented March 8th, 1900.

The rapidly increasing use of asphalt as a material for engineering construction demands a thorough scientific investigation of the properties of that substance as a matter of practical necessity. At one time nearly all of the asphalt used in this country was imported; now, there are many American asphalts, besides numerous artificial products. These various kinds of asphalts differ in many of their characteristics, and one might think that it was comparatively easy to determine their relative suitability for various uses, but when it is remembered that they may be mixed with each other in almost any proportion, the complexity of the problem becomes apparent. The practical tests to be applied to asphalt are largely physical. It is useful to know their chemical composition, but it is more important to know their consistency, viscosity, elasticity, ductility, fracture, etc., and the relative importance of these tests varies with the nature of the work for which the asphalts are to be used.

In many places, if not in most places, where asphalt is used, its surface is subjected to the action of water. Street pavements are being continually washed by rains, and during the winter the surface of the asphalt may be for a long time in contact with snow and ice. The various forms of asphalt paints are intended primarily to protect metallic substances from weathering and from the corrosive action of

* This Club is not responsible, as a body, for the facts and opinions advanced in this publication.

water. The use of asphalt as a lining for reservoirs brings this subject into still greater prominence. Here the contact with water takes place under various conditions. Above the water line the asphalt surface may be alternately wet and dry; near the water line it is subjected to the erosive action of the waves and to the force of the ice in winter; while at the bottom of the reservoir there is the effect of pressure.

It is evident that one of the first requisites of an asphalt for reservoir lining is that it shall not be injuriously acted upon by water, either physically or chemically. If such an action does take place, the efficiency of the substance is impaired and the life of the structure reduced. Experience has shown that some asphalts are acted upon by water to a considerable extent, while others are apparently unaffected. The following investigation was undertaken to determine the relative action of water upon some of the most important asphalts on the market, with reference to their use for reservoir lining.

The refined asphalts used for the experiments were the following:

1. Trinidad Lake asphalt.
2. Bermudez asphalt.
3. Alcatraz asphalt, Grade D.
4. Alcatraz asphalt, Grade XX.
5. Alcatraz maltha, No. 1.
6. Alcatraz maltha, No. 2.
7. Cuban asphalt, No. 1.
8. Cuban asphalt, No. 2.
9. Assyrian asphalt, No. 2.*
10. Assyrian asphalt, No. 3.
11. Assyrian asphalt. No. 4.
12. Assyrian asphalt, No. 5.
13. Assyrian asphalt, No. 6.
14. Assyrian asphalt, No. 7.
15. Asphaltina.
16. Asphaltina mixed with Cuban.
17. Petroleum residuum.

* The Assyrian asphalts were used for the following purposes:

No. 2. Matrix for reservoir concrete bottom.
No. 3. Matrix for top mastic for reservoir bottom.
No. 4. Top coating over bottom and sides of reservoir, to finish.
No. 5. Asphalt paint.
No. 6. Mastic work for sides, on stone, under brick.
No. 7. Hot dip for brick for sides of reservoir.

Samples Nos. 1 to 6 were personally collected at the yards of the respective companies; the samples being selected with great care from large masses. Samples 7 to 17 were not personally collected.

The experiments were conducted along three lines: First, that of placing samples of the asphalts in contact with water in glass jars and subsequently noting the change in the analysis of the water; thereby ascertaining the nature of the soluble constituents of the asphalts. Second, that of immersing samples of the asphalts in water under various conditions and noting their change in weight. Third, that of observing the action of water upon the asphalts by noting changes in their physical condition.

In order to study the soluble constituents, the asphalts were melted and poured into glass jars so as to form a layer at the bottom about 1 cm. thick, and having an average area of about 60 sq. cms.; 800 cu. cm. of water were then added, and the jars closed to present evaporation. Two jars were used for each sample, one being filled with distilled water and the other with surface-water* from the eastern part of the Brooklyn water-shed. In the case of the Trinidad and Bermudez asphalts a third jar was prepared and filled with water from some of the deep wells of the Brooklyn water supply. At the end of two months a portion of the water in each jar was removed and analyzed. After two years the remaining water was subjected to analysis. The sample of asphaltina was not received until December, 1898, and consequently the analysis represents but one year's action.

For the second series of experiments the asphalts were melted at as low a heat as possible and poured into watch-glasses, where they spread out into thin cakes with smooth surfaces. These cakes contained equal amounts of asphalt and presented surface areas that varied from 45 to 55 square centimeters. The watch-glasses, with their adhering cakes of asphalt, were dried in desiccators and weighed. They were then mounted on agate-ware plates, fastened with copper wire, and suspended in water. In order to determine the effect of different waters, and of different conditions, such as pressure, temperature, light, current, etc., the Trinidad, Bermudez, and Alcatraz D asphalts were suspended in Mt. Prospect Reservoir near the surface, where the pressure was small and the temperature changes considerable; in Mt. Prospect Standpipe, at a depth of 50 ft., where they were

* This "surface water" is really a mixture of water from ponds and driven wells.

in darkness, where the pressure was great and also variable, and where the changes of temperature were small; and in the conduit at Freeport where they were subjected to the action of water different in quality from the two preceding, where the pressure was small, but the current strong. The remaining asphalts were exposed in but one place. From time to time the samples were withdrawn from the water, and cleansed by washing with distilled water and rubbing with a fine camel's-hair brush. They were then dried in desiccators, weighed, and replaced in the water.

The action of the water upon the various asphalts was observed in both sets of experiments by inspection and by microscopical examination of the surface; and in the first set, by measurement of the depth to which the action of the water extended during two years' exposure. The results of these observations were as follows:

No. 1. Trinidad Lake Asphalt.—The action of the water upon this asphalt was strong. Two weeks' exposure caused a roughening of the surface and a change in color from black to brown. With longer exposure the brown color was more conspicuous, and the surface became granular. Finally, the upper portion of the asphalt changed to a soft punky material, covered with cracks and pits. In the jars a thin layer of loose material had become more or less detached from the surface. The samples that stood in the jars for two years were examined in cross-section under the microscope, and the depth of the action determined by careful measurement. In the distilled water the soft, brown surface layer was 1.32 mm. thick; in the surface water, it was 1.12 mm.; and in the well water, it was 1.10 mm.

No. 2. Bermudez Asphalt.—The action of the water upon this asphalt was noticeable and similar in character to that just described, but it proceeded much more slowly and was far less in amount. For a long time the surface remained black, but later it became brownish. At first there was a slight cracking of the surface, but afterward the surface became wrinkled. In the jars the depth of action was .03 mm. in distilled water; .02 in the surface water, and .01 in the well water.

No. 3. Alcatraz Asphalt, Grade D.—There was a slight, but measureable action upon this asphalt. The color changed from black to brown, but the surface remained quite smooth. The depth of action in the jars was .005 mm.

No. 4. Alcatraz Asphalt, Grade XX.—This asphalt showed greater action than the preceding, and almost as much as the Bermudez. At the end of two years the surface of the asphalt in the jar was brown and wrinkled. The depth of action was .015 mm. in distilled water, and .010 mm. in the surface water and in well water.

No. 5. Alcatraz Maltha No. 1.—The action of the water upon this maltha was confined to a thin film at the surface. The color changed from black to brown, but, on drying, the brown color almost disappeared.

No. 6. Alcatraz Maltha No. 2.—The action was not quite as strong as in the case of Maltha No. 1.

No. 7. Cuban Asphalt No. 1.—This asphalt had a hard, shining surface and was exceedingly brittle. There was no apparent action.

No. 8. Cuban Asphalt No. 2.—This asphalt is also very brittle. There was a very slight action at the surface, with a change in color from black to brown. The depth of the action was too small to be measured.

No. 9. Assyrian Asphalt No. 2.—There was no apparent action.

No. 10. Assyrian Asphalt No. 3.—There was no apparent action.

No. 11. Assyrian Asphalt No. 4.—There was almost no action, though in one case the surface was very slightly browned.

No. 12. Assyrian Asphalt No. 5.—This asphalt was considerably acted upon. The color was decidedly brown and the surface spongy. The depth of action was .02 mm. in distilled water and .01 mm. in the surface water. This product is not intended to be used in contact with water.

No. 13. Assyrian Asphalt No. 6.—There was no apparent action.

No. 14. Assyrian Asphalt No. 7.—There was no apparent action.

No. 15. Asphaltina.—There was a very slight action, but it was too small to be measured.

No. 16. Asphaltina Mixed with Cuban.—There was no apparent action.

No. 17. Petroleum Residuum.—There was no apparent action.

The following table shows the depth of the action of distilled water, surface water and well water on the various asphalts. It should be remembered that these figures have only a relative value as the conditions of the experiments were different from those of actual practice.

TABLE I.—Action of Distilled Water, Surface Water and Ground Water Upon Various Asphalts After Two Years' Exposure in Glass Jars.

Asphalt.	Depth in Millimeters to Which the Action of the Water was Observed.		
	Distilled water.	Surface water.	Ground water.
Trinidad Lake Asphalt	1.320	1.120	1.100
Bermudez Asphalt	0.030	0.020	0.010
Alcatraz Asphalt, Grade D	0.005	0.005	trace.
Alcatraz Asphalt, Grade XX	0.015	0.010	......
Alcatraz Maltha, No. 1	trace.	trace.	......
Alcatraz Maltha, No. 2	trace.	trace.	......
Cuban, No. 1	0.000	0.000	......
Cuban, No. 2	trace.	trace.	......
Assyrian, No. 2	0.000	0.000	......
Assyrian, No. 3	0.000	0.000	......
Assyrian, No. 4	0.000	trace.	......
Assyrian, No. 5	0.020	0.010	......
Assyrian, No. 6	0.000	0.000	......
Assyrian, No. 7	0.000	0.000	......
Asphaltina	trace.	......	......
Asphaltina mixed with Cuban	0.000	......	......
Petroleum Residuum	0.000	0.000	......

The results of the experiments made to determine the soluble constituents of the asphalts are given in Tables II, III and IV.

Table II shows the loss from the asphalts after two months' exposure in the jars, obtained by analysis of the supernatant water, as before described. The results are expressed in "grams per square metre of exposed surface." The figures in the first horizontal line represent the total solid matter taken up by the water; those in the second line, the amount of organic matter volatile at a temperature just sufficient to redden platinum; those in the third line, the fixed solids.

It will be seen that to a certain extent the amount of soluble matter corresponds with the intensity of the action of the water upon the asphalts. For example, in almost every case the action was greatest in the jars that contained distilled water; and in those jars, also, the largest amounts of soluble matter were taken up by the water. The water over the Trinidad asphalt contained more soluble matter than most of the other samples and this asphalt was acted upon the most strongly. The correspondence between action of water and soluble matter was not perfect, however. Assyrian asphalt No. 5 gave up a phenomenally large amount of soluble matter in propor-

TABLE II.—LOSS FROM VARIOUS ASPHALTS EXPOSED FOR TWO MONTHS TO THE ACTION OF WATERS OF DIFFERENT QUALITY IN GLASS JARS.

(In Grams per Square Meter of Exposed Surface.)

	Trinidad Lake Asphalt.			Bermudez Asphalt.			Alcatraz D Asphalt.		Alcatraz XX Asphalt.		Alcatraz Maltha No. 1.		Alcatraz Maltha No. 2.		Cuban Asphalt No. 1.	
	Distilled water.	Surface water.	Ground water.	Distilled water.	Surface water.	Ground water.	Distilled water.	Surface water.	Distilled water.	Surface water.	Distilled water.	Surface water.	Distilled water.	Surface water.	Distilled water.	Surface water.
Total solids.....	2.53	1.44	1.87	1.23	1.32	0.46	0.84	0.96	1.37	0.51	1.29	1.20	1.50	1.08	1.31	0.34
Loss on ignition..	0.72	0.24	0.36	0.72	0.36	0.18	0.30	0.32	0.40	0.40	0.72	0.54	0.60	0.54	0.57	0.23
Fixed solids.....	1.81	1.20	1.51	0.51	0.96	0.28	0.54	0.64	0.97	0.11	0.57	0.66	0.90	0.54	0.74	0.11

	Cuban Asphalt No. 2.		Assyrian Asphalt No. 2.		Assyrian Asphalt No. 3.		Assyrian Asphalt No. 4.		Assyrian Asphalt No. 5.		Assyrian Asphalt No. 6.		Assyrian Asphalt No. 7.		Petroleum Residuum.	
	Distilled water.	Surface water.	Distilled water.	Surface water.	Distilled water.	Surface water.	Distilled water.	Surface water.	Distilled water.	Surface water.	Distilled water.	Surface water.	Distilled water.	Surface water.	Distilled water.	Surface water.
Total solids.....	0.86	0.51	1.37	0.46	1.03	0.40	1.14	0.91	8.51	5.83	1.20	0.17	1.31	0.51	1.20	1.14
Loss on ignition..	0.00	0.23	0.23	0.29	0.46	0.18	0.29	0.23	7.14	5.57	0.74	0.17	1.14	0.45	0.42	0.36
Fixed solids.....	0.86	0.28	1.14	0.17	0.57	0.22	0.85	0.68	1.37	0.26	0.46	0.00	0.17	0.06	0.78	0.78

TABLE III.—LOSS FROM VARIOUS ASPHALTS EXPOSED FOR TWO YEARS TO THE ACTION OF DISTILLED WATER IN GLASS JARS.

(In Grams per Square Meter of Exposed Surface.)

	Trinidad Lake Asphalt.		Bermudez Asphalt.		Alcatraz Asphalt. D.		Alcatraz Asphalt. XX.		Alcatraz Maltha. No. 1.		Alcatraz Maltha. No. 2.		Cuban Asphalt. No. 1.		Cuban Asphalt. No. 2.		Assyrian Asphalt. No. 2.	
	Total.	In solution.	Total.	In solution.	Total.	In solution.	Total.	In solution.	Total.	In solution.	Total.	In solution.	Total.	In solution.	Total.	In solution.	Total.	In solution.
Total solids.....	79.33	19.25	21.17	16.67	21.42	18.67	6.33	4.50	11.76	5.92	12.42	10.08	3.75	3.75	2.83	2.83	5.17	5.17
Loss on ignition.	42.80	4.77	8.83	6.17	5.92	3.92	3.42	2.75	6.59	2.50	8.62	6.17	1.50	1.50	.92	.92	4.67	4.67
Fixed solids....	36.53	14.48	12.34	10.50	15.50	14.75	2.91	1.75	5.17	3.42	3.80	3.91	2.25	2.25	1.91	1.91	0.50	0.50

	Assyrian Asphalt. No. 3.		Assyrian Asphalt. No. 4.		Assyrian Asphalt. No. 5.		Assyrian Asphalt. No. 6.		Assyrian Asphalt. No. 7.		Asphaltina.		Asphaltina and Cuban.		Petroleum Residuum.	
	Total.	In solution.	Total.	In solution.	Total.	In solution.	Total.	In solution.	Total.	In solution.	Total.	In solution.	Total.	In solution.	Total.	In solution.
Total solids.....	9.25	9.25	9.75	6.83	17.93	17.93	8.92	4.58	9.08	6.08	4.75	3.67	8.08	8.08	2.25	2.25
Loss on ignition.	4.85	4.85	5.75	5.17	16.17	16.17	3.17	2.83	4.83	3.17	3.13	2.92	4.17	3.92	2.08	2.08
Fixed solids.....	4.40	4.40	4.00	1.66	1.76	1.76	5.75	1.75	4.25	2.91	1.62	0.75	3.91	4.16	0.17	0.17

tion to the extent of the surface action, while a few of the asphalts that were apparently unacted upon, gave up some soluble matter, both organic and mineral.

In Table III are given the results of the analysis of the distilled water made at the end of two years. The total solids and loss on ignition were made both before and after filtration through paper, in order to separate the material in suspension from that in solution. The results are naturally higher than those given in Table II, but they present but few additional points of interest. In the case of the Trinidad asphalt, it will be observed that most of the matter is in suspension, This shows, in a general way, the greater amount of disintegration that has taken place.

The organic matter represented by the loss on ignition was asphaltic in character. During ignition it blackened and gave off the characteristic odor. This odor could be detected in the waters in the jars, and was found to correspond in intensity to the amount of action that had taken place. Some idea of the character of the fixed solids may be obtained from the following table:

TABLE IV.—Mineral Constituents given up by the Trinidad, Bermudez and Alcatraz D Asphalts (Exposure of Two Months in Glass Jars).

Constituents dissolved.	Trinidad Lake Asphalt.			Bermudez Asphalt.			Alcatraz Asphalt D.	
	Distilled water.	Surface water.	Ground water.	Distilled water.	Surface water.	Ground water.	Distilled water.	Surface water.
Fixed solids	1.81	1.20	1.51	0.51	0.96	0.28	0.54	0.64
Sodium chloride (Na Cl.)	0.42	0.60	0.60	0.18	0.79	0.09	0.00	0.00
Carbonates and sulphates of Calcium and Magnesium	0.48	0.42	0.42	0.00	0.05	0.00	0.00	0.00
Oxide of Iron (Fe_2O_3)	0.06	0.12	0.06	0.00	0.00	0.00	0.00	0.00

The results of the second series of experiments are given in Table V, which shows the increase in weight of each sample after exposures of one day, one week, and two months.

TABLE V.—INCREASE IN WEIGHT OF VARIOUS ASPHALTS DURING EXPOSURE TO WATERS OF DIFFERENT QUALITY AND UNDER DIFFERENT CONDITIONS.

(In Grams per Square Meter of Exposed Surface.)

Time of Exposure.	Trinidad Lake Asphalt.			Bermudez Asphalt.			Alcatraz Asphalt D.		
	Conduit at Freeport.	Mt. Prospect Reservoir.	Mt. Prospect standpipe.	Conduit at Freeport.	Mt. Prospect Reservoir.	Mt. Prospect standpipe.	Conduit at Freeport.	Mt. Prospect Reservoir.	Mt. Prospect standpipe.
One day	....	3.92	5.25	....	1.02	7.71	....	1.09	1.81
One week	....	21.54	34.79	....	3.88	8.42	....	3.50	4.77
Two months	84.41	31.24	137.09	4.86	5.96	11.02	5.86	6.93	10.39

Time of Exposure.	Alcatraz Asphalt. XX.	Alcatraz Maltha. No. 2.	Cuban Asphalt. No. 2.	Assyrian Asphalt. No. 2.	Assyrian Asphalt. No. 3.	Assyrian Asphalt. No. 4.	Assyrian Asphalt. No. 7.
	Mt. Prospect standpipe.		Mt. Prospect Reservoir.				
One day	....	....	....	....	....	....	....
One week	2.82	4.73	4.91	1.79	1.22	0.74	0.93
Two months	....	8.65	7.17*	2.54*	1.54*	3.41	1.12*

* One month.

The greatest increase of weight was observed in the case of the Trinidad asphalt. The sample exposed in Mt. Prospect Reservoir gained 3.92 grs. per square meter in one day; after two months it had gained 31.24 grs. The gain in weight varied with the conditions of exposure. In the conduit at Freeport the gain in weight during two months was 84.41 grs.; in Mt. Prospect standpipe, where the pressure was great, it was 137.09 grs. This is equivalent to a gain in weight of 4 ounces per square yard of exposed surface.

The gain in weight of the other samples was less, but corresponded, in a general way, with the amount of action observed.

Richardson has also observed that asphalt gains in weight when exposed to the action of water. In his paper on "Softening Agents for the Production of Asphaltic Cement" † he says: "Surfaces of the pure bitumen from asphalt, of the asphalt cement made with it and residuum, and of coal tar, were prepared in glass beakers, each having

† *Municipal Engineering Magazine*, June, July, August, 1897.

an area of 16 square centimeters. These surfaces were covered with water and exposed to its action for a year, being weighed at intervals." The results are given in the following table, recalculated from the original figures, and expressed in grams per square metre of exposed surface:

TABLE VI.—GAIN IN WEIGHT OF ASPHALTS AND COAL TAR UPON EXPOSURE TO WATER. (Recalculated from Richardson.)

(In Grams per Square Meter of Exposed Surface.)

	Time Elapsed.						
	One Week.	1 Month	2 Months	4 Months	6 Months	9 Months	12 Months
Bermudez Refined Asphalt....	2.5	10.6	15.6	34.4	36.9	47.5	60.0
Bermudez Asphalt Cement....	0.8	13.7	30.0	36.3	39.4	50.0	65.7
Coal Tar........................	1.3	13.2	14.5	28.9	29.4	32.5	44.4

It will be seen from this table that the asphalt cement was slightly more acted upon than the refined asphalt, and that the coal tar was acted upon the least.

The cause of the action of water upon asphalt appears to be in part chemical and in part physical. In the article just quoted Richardson has suggested that the molecular structure of the asphalts is an important consideration. He has given a table, showing the relative effects of different strengths of sulphuric acid upon petroleum residuum, Alcatraz maltha and the hard Alcatraz asphalt, from which it is seen that the maltha and hard asphalt are less saturated in their composition than the petroleum residuum, and are acted upon more strongly by sulphuric acid. "In consequence it is but reasonable to suppose that the same relations exist in their ability to withstand the action of water."

"The saturated and permanent character of the residuum as compared to the maltha and asphalt is also shown by their ultimate composition:

	Carbon. Per cent.	Hydrogen. Per cent.
Residuum after treatment with acid......................	84.74	15.33
Maltha after treatment with acid........................	86.86	13.10
Asphalt..	88.25	11.75

The residuum has the composition of a saturated hydrocarbon, while the maltha and asphalt have that of the unsaturated series."

Asphalt has the property of physically absorbing a certain amount of water. This accounts in part for the increase in weight given in the above tables. It has been found that if the brown, punky material is removed from the surface of asphalt which has been acted upon and is kept for several days in the desiccator over sulphuric acid, it will lose weight on drying at 100° Cent. In the case of Trinidad asphalt this loss is about 0.8% of the original weight. Not all of the water is driven off at this temperature, but enough is removed so that a definite change takes place, for the material changes from a brown inert powder to an elastic substance with apparently the properties of the original asphalt, except that the color is very dark brown instead of black. That it has not exactly the same composition as the original asphalt, however, was shown by the following experiment. Portions of this dark brown material and of the original Trinidad asphalt were dried for six hours at 100° Cent. and compared by making combustions of each in a Mahler bomb calorimeter. The following results were obtained:

	Original asphalt after heating at 100° Cent.	Asphalt acted upon by water, after heating at 100° Cent.
B. T. U.	10 246.	10 042.
Ash	37.7%	36.8%
Nitrogen	1.97%	1.92%
Volatile sulphur	3.51%	3.10%

It will be seen that there was a loss of about 200 British Thermal Units, and a loss of 0.4% of sulphur. This loss in sulphur does not entirely account for the loss in thermal units, and it must be assumed that, in the course of the action by the water, the asphalt became oxidized, and that a change occurred beyond that to be accounted for by the loss in sulphur.

As a check upon this result, the same experiment was repeated, but the substances were first heated two hours at 110° Cent. At the end of this time the samples had lost from 1.4% to 2.4% in weight, showing by these varying amounts that the water present was probably not in chemical combination. At the same time oxygen had been taken up in the heating, as shown by the loss in heat units.

The following table shows the same relative results as the previous one:

	Original asphalt after heating at 110° Cent.	Asphalt acted upon by water, after heating at 110° Cent.
B. T. U.	10 112.	9 974.
Ash	37.57%	35.39%
Nitrogen	2.13%	1.95%
Volatile sulphur	3.48%	2.94%

It will be seen from this table that the asphalt, in spite of the fact that it had lost over 1% more water than in the first experiment decreased in British Thermal Units, showing that it had taken on a considerable amount of oxygen.

Endemann* has noted the avidity with which asphalt absorbs oxygen at high temperatures and the change in its physical condition when heated at 250° Cent. in a current of air.

As tests for hydrogen sulphide have been found in water which has stood for some time over asphalt, it must be concluded that to this extent the water itself acts chemically upon the asphalt, and that some of the loosely combined sulphur is replaced by oxygen, with the consequent liberation of hydrogen sulphide.

Throughout the course of the investigation it was observed that the waters that contained the smallest amounts of mineral matter produced the greatest action upon the asphalts. Sea water gave but little action. In order to obtain comparative results upon this point, samples of various asphalts were subjected to the action of distilled water, sea water, and a concentrated brine solution in glass jars. After two months it was found that the distilled water showed considerable action, the sea water a very slight action, and the brine no apparent action.

Some of the brine solution was allowed to stand over the surface of an asphalt that had been already acted upon by water. No change in the brown material took place. This seemed to indicate that the salt itself exerted no chemical action upon the asphalt.

A determination of the dissolved oxygen in the distilled water, sea water, and brine gave the following results:

* "The Analysis of Asphalt," *Journal* of the Society of Chemical Industry, Vol. xv, No. 12, December, 1896, and Vol. xvi, No. 2, February, 1897.

	Dissolved oxygen per liter.
Distilled water	7.1 cubic centimeters.
Sea water	4.8 " "
Brine	0.6 cubic centimeter.

These facts show conclusively that the action of water upon asphalt is largely one of oxidation and is due to the oxygen dissolved in the water. As a final test, however, a sample of Trinidad asphalt was covered with water which had been boiled until free from oxygen, and then tightly sealed to prevent absorption from the air. The action that took place under these conditions was very slight. It appears, therefore, that water acts chiefly as a carrier of oxygen, and does not, to any great extent, give up the oxygen of its own composition.

As a practical example of the effect of water upon asphalt used for reservoir lining, the following is perhaps the best instance that can be cited. About eight years ago the reservoirs of the Citizens' Water Company, of Denver, Colo., were lined with asphalt. These reservoirs, known as the East and West Ashland Avenue Reservoirs, have the following dimensions:

West Reservoir: bottom, 341 by 256 ft.; top, 350 by 420 ft.; maximum depth, 32 ft.; side slopes, 1.33 to 1; capacity, 22 000 000 galls. East Reservoir: bottom, 152 by 494 ft.; top, 236 by 580 ft.; depth, slopes and capacity the same as the West Reservoir.

The West Reservoir was lined with Trinidad asphalt in 1891; the East Reservoir was lined with California asphalt in the summer of 1892. A description of this work may be found in a paper by James D. Schuyler on "The Use of Asphaltum for Reservoir Linings," in the *Transactions* of the American Society of Civil Engineers, Vol. XXVII, December, 1892.

In 1893 Schuyler stated that the reservoir which was lined with Alcatraz asphalt was in good condition, while the reservoir which was lined with Trinidad had shown signs of deterioration. At the present time, however, both reservoirs are in a very unsatisfactory condition. The appearance of the asphalt linings is shown by four samples kindly furnished by Mr. C. P. Allen, C. E., Chief Engineer of the Denver Union Water Company. The samples represent the condition of the surface of the asphalt in each reservoir above and below the line of high water.

The action of water upon asphalt is due to the unsaturated nature of the hydrocarbons present, and is attended by a partial solution of the asphalt in the water. There is also a loss of sulphur as hydrogen sulphide, and an increase in weight of the asphalt itself due to oxidation and to the mechanical admixture of water. By far the most important action which occurs, is that produced by this oxidation of the asphalt by means of the dissolved oxygen in the water.

The following asphalts and fluxes are arranged in the order of least to greatest action by water:

Petroleum residuum.
Assyrian asphalt.
Asphaltina.
Cuban asphalt.
Alcatraz maltha, No. 2.
Alcatraz maltha, No. 1.
Alcatraz asphalt, D.
Alcatraz asphalt, XX.
Bermudez asphalt.
Trinidad Lake asphalt.

The authors desire to express their thanks to Mr. Robert Van Buren, C. E., Engineer-in-charge, Department of Water Supply, Brooklyn, N. Y., for permission to quote from unpublished reports of the laboratory, and to Mr. I. M. De Varona, C. E., Engineer of Water Supply, under whose direction the experiments on asphalt were made.

DISCUSSION.

The PRESIDENT.—The Chair has no hesitation in saying that this paper is one of greater interest and value on the physical properties of asphalt than probably anything that has been written and made public. The action of water upon asphalt has always been known, but this is the first time within my knowledge (and I have tried to keep pretty well informed on the literature of the subject) that any systematic attempt has been made to ascertain the action of water upon the different asphalts enumerated. The President.

The subject is now open for discussion, and there are quite a number of people here whom I know are not only interested, but who have given the matter a good deal of thought, and we would be glad to hear from them on the subject.

Mr. BROADHURST.—I would like to ask the authors if they have tried the effect of heating this brown powder? Mr. Broadhurst.

Mr. JACKSON.—The asphalt changes from brown to black, and, apparently, has the same properties as the original black asphalt, but the analysis shows it to be considerably altered in its composition. Mr. Jackson.

Mr. BROADHURST.—Have you ever tried the solvent action of naphtha or chloroform on the brown powder? Mr. Broadhurst.

Mr. JACKSON.—No. Mr. Jackson.

Mr. BROADHURST.—We have been conducting some experiments along this line in the laboratory of the Department of Highways, and we find that our results go to confirm the results of the authors in a very interesting manner. Mr. Broadhurst.

We find that the action on Trinidad asphalt is greatest, and this is for several reasons. One is that there is a considerable amount of soluble salts in Trinidad asphalt which, when dissolved, would render the pavement porous, causing the oxygen dissolved in the rain water to act more freely. And, in the second place, I think that there is an oxidation induced by the presence of a large amount of organic matter, non-bituminous, which consists of an oxygen derivative of asphaltene, and, also, vegetable matter.

This brown powder which is mentioned in the paper is lightest in color, I find, in the Trinidad asphalt. I have heated the brown powder resulting from the oxidation of Trinidad asphalt, at 212° Fahr., and find that it changes to black, as the authors have mentioned. But I do not think this would indicate a change in composition.

There are certain deposits of Gilsonite out in Colorado which are practically pure asphaltenes. They contain no petrolene whatever. If you pulverize a portion of one of these Gilsonites you get a brown powder. If you heat this brown powder at 212° Fahr. you get a black

Mr. Broadhurst. powder, resembling the original Gilsonite, that is, has the appearance of coal—looks like anthracite as much as anything.

That the disintegration of asphalt by water is caused by oxidation, there can be no doubt. The dissolved oxygen in the rain water oxidizes the asphalt, but I think it acts in this way: I think that the action in the first place is an indirect oxidation; that one atom of oxygen combines with two atoms of hydrogen of the hydrocarbon, and a molecule of water splits off; and subsequently there is evidently a direct oxidation of the asphaltene so formed.

I have the samples which we have been experimenting on here, and will pass them around. I might also say that we have some samples that have been placed in salt water, and they show no action whatever. These samples are made up from paving mixtures, which contain petroleum residuum in the asphaltic cement of the Trinidad and Bermudez samples, and maltha in the case of the Alcatraz.

The President. The President.—It is true, isn't it, that these experiments made by the authors were made on the refined asphalt? On the paving material the action would be very much more.

Mr. Jackson. Mr. Jackson.—The experiments described were all made upon the refined asphalts. In those cases where we have tried the paving mixtures, they have disintegrated more rapidly.

Mr. Broadhurst suggests that the action of oxygen in the water may take away hydrogen from the asphalt itself to form water. If this theory were correct, then the heating power of the original asphalt as shown by the calorimeter would be considerably reduced, as hydrogen even in close combination has a high calorific power. As a matter of fact, the results show that there is only a slight reduction, a reduction of $1\frac{1}{2}$ to 2% in British Thermal Units, which it would seem would merely account for an addition of oxygen, and not a subtraction of hydrogen.

Mr. Broadhurst. Mr. Broadhurst.—Do you find any oxygen in this brown powder?

Mr. Jackson. Mr. Jackson.—Dr. Endemann, who has made experiments upon this question, found that the asphalt on exposure changes by the addition of oxygen to what he calls asphaltic acid.

Mr. Broadhurst. Mr. Broadhurst.—It has been proved by Richardson that any portion of the bitumen which has changed to an oxygen derivative is insoluble in chloroform, and can no longer be regarded as bitumen. I have tried to dissolve this brown powder in chloroform. I find there is quite an amount soluble in chloroform, but a considerable portion is insoluble. The insoluble portion is probably an oxygen derivative.

Mr. Meem. Mr. Meem.—I would like to ask if any experiments have been made with these asphalts under pressure—that is under conditions to which they would be subjected if the asphalt binding were covered with brick or concrete—for instance, by placing a layer of asphalt in a test-tube and covering it with a layer of cement, then filling the

tube with water. I should like to ask if there were any experiments of that kind made. Mr. Meem.

I do not know whether I make myself clear, but when it is desired to get a waterproof material, it is generally made by layers of asphalt or roofing felt between layers of concrete or brick. I know that a good many reservoirs as well as other waterproof structures have been made that way, the Queen Lane reservoir among others being lined with brick over asphalt.

The PRESIDENT.—As I understand Mr. Meem, the idea is, whether the pressure of the concrete or brick upon the asphalt would have any effect upon interfering with the action of the water. The President.

Mr. MEEM.—Not that exactly, but to what extent the concrete or brick protects the asphalt lining. I should like to know the results of any experiments along this line, or whether these conditions have ever been studied as in actual use. Mr. Meem.

Mr. JACKSON.—I am inclined to think the concrete would serve, to quite an extent, as a protection against the action of water upon the asphalt, and that the best reservoir lining would be brick set in asphalt mixture and covered by a thin layer of concrete. Mr. Jackson.

Mr. MEEM.—I think Mr. Vail can tell us the method of construction adopted in the Queen Lane reservoir, and he may also know how it is standing the test of time. Mr. Meem.

Mr. VAIL.—It was lined with Bermudez—first with concrete or brick, I forget which, set in cement, and then a coat of asphalt, and burlap over that, and another coat of asphalt, and then a layer of brick next to the water. I see no reason why the action of water should not be just as great in that case as if exposed to water direct, except that a current might wash the brown powder off where the surface was exposed. Mr. Vail.

I think experiments were made in the same line, which confirm everything that the authors have said, except that our material did not work as uniform. We got some of the worst results from our own material, and, of course, we never have published them.

I think that the brown powder on the surface somewhat protects the material underneath. I suppose that that would be found only by a very extended course of experiments. It might take quite a number of years to measure it. Something that was rather surprising to me was the slight effect upon Alcatraz liquid asphalt, malthas, because our experiments show that our hardest material stood the water best, and the experiments just described in other materials showed something like the same effect.

The Cuban asphalts, which are very brittle, and are practically, I think, useless for any purpose such as paving, were practically not taken at all. I do not know what the consistency was of the many different grades of Assyrian asphalts.

Mr. Vail. I think one reason why the Denver reservoir has not turned out as well as some others we have lined, is that it was lined with our earlier product, which was about 80 per cent. bitumen. That was as far down as we could find it in those days, and the surface was compressed by means of rollers, up and down the slope.

You cannot get any top mixture of sand and dust and asphalt which will stand against the weather if there is no traffic under it, and in the case of a reservoir there is nothing to keep it compressed in any way, as in the case of street traffic.

In other reservoirs which we have lined and given a heavy coating of pure bitumen, they have all shown the change in color, and a slight softening on the surface, but it has never seemed to grow any worse after the first year, so that I think that all that have been lined with Alcatraz asphalt that I know of, except the Denver reservoir, are in good condition. That was the second one we lined. The one lined earlier than this is in good condition. A reservoir in San Francisco was lined in 1893 with concrete, with a thin coating of asphalt, and no burlap was used.

I think that the only way to line a reservoir with asphalt, to make it permanent, is to put it between two layers of concrete or brick, and then I think that it is certainly good for a very long time, because the action shown by laboratory experiments extending over 2 years indicates that the depth of deterioration is very slight, and probably if a ½-in. layer were put in it would be good for a lifetime.

The President. The PRESIDENT.—I understand from what Mr. Vail has said that this San Francisco reservoir contained salt water.

Mr. Vail. Mr. VAIL.—Yes.

Mr. Lewis. Mr. N. P. LEWIS.—I would like to ask how this reservoir lining in Denver was put on, and to what thickness. These specimens exhibited show 1½ or 2 ins. of material. If I recall correctly the statements in Mr. Schuyler's paper, which has been referred to, the asphalt was put on as an extremely thin coating. I think in Portland or Astoria, the concrete sides of the reservoir were scarcely more than painted, the slopes having been treated with something like gasolene, and then a very thin coating of asphalt put on.

Mr. Vail. Mr. VAIL.—The Denver reservoir was lined with a mixture of sand, and it was a paving mixture, but a very poor mixture. Ours was lined simply with 80% of sand and 10% of asphaltic cement—no filler. It was very close, and well graded on the surface, but the Portland reservoirs were lined with concrete or brick, and that was simply painted with pure asphalt—asphalt and gasoline in the proportion of 1 to 3. In that way you get a very thin coating that would penetrate concrete, so that hot asphait coming on top would stick. If you put hot asphalt on concrete you will get a dew on it which will prevent the asphalt from sinking. So you have got to use a coat of paint first of all.

That, I think, they put on the Denver reservoir, if I remember rightly, 1½ ins. thick. Mr. Vail.

Mr. N. P. Lewis.—There is one curious idea which seems to be most persistent, and for which there is apparently little ground, and that is the deleterious effect of salt, or salt water, upon asphalt pavements. Mr. Lewis.

A short time ago I had some correspondence with a recognized authority on pavements, who was at that time preparing a report upon the advisability of laying a supplementary system of water mains for fire and street cleaning purposes in Manhattan, and the question was raised whether or not the salt water would be injurious to the asphalt pavements. Attention is frequently called to the condition of the asphalt pavement in front of ice cream saloons. In the Alcatraz pavement on Clinton street, and in many other places from which ice cream is sent out in large quantities, you will find holes in the pavement. This is generally charged to the salt water coming from the freezers.

It seems to me that the trouble can be explained by the fact, not that the water is salt, but that it has an extremely low temperature when it is poured over the pavement in midsummer, when the latter has a very high temperature. The asphalt pavement is apt to be up in the nineties in midsummer, and while at this temperature the liquid, below the freezing point, is suddenly thrown upon it. I believe that would seriously affect almost any material, and I am not surprised that the asphalt fails, and I think that this is very probably the secret of its failure. It is subjected to a sudden and sharp change of temperature of 60° to 70°, and no material—no artificial mixture, such as asphalt—in my judgment, will stand such a shock. As we all know, the greatest damage to asphalt pavements is caused by extreme changes in temperature.

Water has always been recognized as an enemy to asphalt pavements, and it has been pointed out that the pavement in the gutter deteriorates most rapidly, particularly when water stands on the surface. In the District of Columbia it has been their practice for the last three or four years to substitute vitrified brick pavement for asphalt for about 2 ft. along the curb, and I am told by the Engineer Commissioner that he considers this change a very advantageous one. Of course, with the very broad streets in Washington, the brick will be subject to almost no wear, there being ample room in the roadways for all vehicles, and the brick simply performs the function, not of a street pavement to carry traffic, but of a gutter to carry surface water, and it is said that the asphalt has been very much more economically maintained.

The President.—There ought to be some advocate of the Trinidad asphalt here. The President.

Mr. Cranford. Mr. Cranford.—Just how water on asphalt affects, or to what degree it is affected, we have never attempted to find out in a scientific way. The chief source of concern to us has been to find out some means of preventing any deterioration.

My object in coming here to-night was to hear an explanation of the difficulty.

I would like to ask Mr. Lewis a question in connection with what he said in regard to asphalt in the gutters in front of ice cream saloons. His explanation as to the action of the cold douche might do in the immediate vicinity of the ice cream manufactories, but would you not think that that small volume of salt water running down, say, 300 ft. over the asphalt pavement would loose its low temperature, and for the last 100 ft. or so would not be affected by the extreme changes of cold which you mention? We find, in one instance, anyway, that the last 100 ft. is just as bad as the first 100 ft.

Mr. Lewis. Mr. Lewis.—That depends, of course, upon the amount of water, the quantity of it.

Mr. Cranford. Mr. Cranford.—I think there must be some action of the salt where it is very strong brine.

Mr. Lewis. Mr. Lewis.—Experiments show that brine is even more favorable.

Dr. Fay. Dr. Irving W. Fay.—I would like to ask a question that suggested itself to me while the paper was being read, and the remarks on it. It was brought to mind in connection with something foreign to asphalt, and that is india rubber.

The chemist of a Montreal rubber shoe firm found that in making rubber cement one day a quantity of the cement wouldn't stick to rubber at all, and he looked into the matter, but couldn't find out anything about it. He stuck at it, however, I think, for three months or more, and finally he did find what seemed to satisfy him, and he reported this. By a microscopical examination of the rubber used in making the cement, he found that it had changed its condition, and become crystalline from age; in that change it had lost its adhesive properties. That would seem to apply also to glass—that where glass has been exposed to the weather it can become devitrified on the surface and become slightly crystallized.

I should like to ask those who have studied the question whether this brown powder, which they say on heating goes back to the black form, is changed if only subjected to 100° temperature, and whether that change has been studied microscopically, or whether the microscope reveals anything in the character of that brown coating which would give any indication in any direction.

Mr. Whipple. Mr. Whipple.—I would say, in answer to that question, that the change from brown to black took place at 100° C., and that we examined that substance with the microscope, and found apparently no difference between it and the original substance. The brown

powder was also amorphous, but different from the black in having no cohesive or adhesive properties. Mr. Whipple.

Mr. Broadhurst.—There is a considerable difference in chemical composition, Mr. President, but there is also a difference in physical; but I think the change from brown to black is a physical change, and not chemical. Mr. Broadhurst.

Mr. Meem.—Referring to that Denver reservoir, I think there were two coatings used there. The first was perhaps 1 in. thick, or an $1\frac{1}{4}$ ins., and I think that was an 85% mixture of sand, and a 15% mixture of asphalt. The second or top coating was perhaps $\frac{1}{2}$ in. thick. Mr. Meem.

Now, another item. I think the authors of this paper could have been saved a great deal of trouble if they had consulted one authority I heard of who answered the Civil Service question, "What effect does water have standing on asphalt?" with, "It seems to make it kind o' rot."

Mr. Provost.—I would like to ask the authors whether their investigation has shown that the amount of oxidation was in any manner proportional to the depth of water over the asphalt. Whether an increased head of water in driving the water further into the asphalt mixture, would carry the oxygen there and cause internal disintegration? Mr. Provost.

Mr. Jackson.—The samples which were exposed in the standpipe, in about 80 ft. of water, showed a very much greater action than those in the reservoir. As the water is practically the same in quality, the increased action must have been due to greater pressure. Mr. Jackson.

Mr. Provost.—The subject chosen by the authors is a very interesting one and of great importance. Mr. Provost.

Their experiments appear generally to add another valuable engineering material to the long list of those whose affinity for oxygen brings despair to the designer.

In 1897 the speaker made some experiments upon some so-called waterproof paints for the purpose of obtaining a covering that would best protect steel girders to be placed underground and subjected to moisture.

One sample experimented with, from which much was expected, was an asphaltic paint prepared and sold by a prominent asphalt company. In order to determine its resistance to penetration of water, a briquette of neat Portland cement about two years old was treated with the paint. The briquette was first dried by heating to remove all moisture and then given a coat of the paint. As might perhaps have been expected, the dry porous cement absorbed the linseed oil or other carrier, leaving a black substance on the surface which could be readily brushed off. The second coat of paint was only partly absorbed, while the third coat gave excellent results. An additional

Mr. Provost. coat was then applied, which, when dry, was an intense lustrous black, with an almost enamel surface. The painted briquette was then carefully weighed and set aside for the paint to harden. After a period of perhaps 10 days the briquette was again weighed and then immersed in about 20 ins. of tap water held in a glass jar. Daily examinations through the sides of the jar soon showed the change in color to brown, as noted by the authors in their experiments. After about 10 days' submersion the briquette was removed and examined. The hard black enamel surface had entirely disappeared, being changed to a soft spongy brown material, which could readily be scraped away with the fingernail.

After drying carefully with a cloth the briquette was again weighed, and was found to have absorbed a considerable amount of water. I am not quite sure of the figures, but I think the absorption was fully 10 per cent. of the weight of the briquette; at all events the tests proved sufficiently the failure of the material for the desired purpose. The speaker is still looking for a paint that will protect metal work against water and dampness.

The President. The PRESIDENT.—If there is no one who has anything more to say, it is possible that I might add something that would be of interest.

Two troubles have arisen from the use of asphalt in lining reservoirs. The first one has been on account of the difficulty of making it stick to the concrete, or with whatever the reservoir happened to be lined, and then the changes in temperature from the night to the day, which on the steep slopes of the reservoir have often caused the asphalt to run down on the side and become thicker in some places than at others. This has been remedied in small reservoirs, as far as the charges of temperature are concerned, by covering them, and I think that this Denver reservoir that has been alluded to was covered. The sunlight was kept from it, as I remember this paper of Mr. Schuyler.

Mr. Lewis. Mr. LEWIS.—It was simply covered by plank, and where the sunlight came through, thin layers of algæ grew on the bottom of the reservoir.

The President. The PRESIDENT.—But the problem of making the asphalts stick to the concrete has been solved in this way: A practically pure bitumen is taken and dissolved in gasoline, and then the masonry is painted with it. The gasolene having such great powers of penetration penetrates the masonry, carrying the bitumen in solution with it, and then, being so volatile, it evaporates, leaving the particles of the bitumen; a second coat of the bitumen can then be applied and it will stick to the first. I think this method was first used in the reservoir at Philadelphia. In the construction of the anchorage for the New East River Bridge they were very particular to get, if possible, a water-tight construction to prevent any moisture from penetrating to the cables. There

they used about the same method, and they had for their first coating, which was dissolved in gasolene, an asphalt (they did not know what variety it was, but I think, from what they told me, that it was Bermudez), that contained 92% of bitumen, which they dissolved in an equal amount of gasolene, and then painted the concrete and the bottom of the anchorage. The President.

Then they made another mixture that contained about 47% of bitumen, and the balance mineral matter, and plastered that on about ½ in. thick, both on the walls and on the bottom. Then a second course of masonry was built inside of that up close to the first wall, so that they had, when it was completed, masonry separated by ½ in. of this asphalt. Of course, it is too soon to get much of an idea of how that is going to act, but it seems to me that it would be very successful.

There is, perhaps, one reason for the difference of the action of water on the Alcatraz and Trinidad asphalts. I do not know, however, why there should be that difference between the Bermudez and the Trinidad; but the Californian asphalts, all of them, have what they call an asphaltic base, while the eastern asphalts have a paraffine base. That is, if the paraffine petroleums are treated with hot air or chlorine they are condensed by evaporation into a substance like vaseline; but if the California oils be treated in the same manner, they are condensed by decomposition into asphalt, showing a somewhat different origin for the two. The Trinidad asphalt belongs to the paraffine base, while all of the Californians, as I said before, have an asphaltic base. But the Bermudez, I should think, ought to give in that respect approximately the same results as the Trinidad, because the sources of the two are very near each other, and a great many people in that locality think that there is a subterranean passage between them, although the Trinidad contains much more organic matter than the Bermudez.

In some parts of California they manufacture asphalt direct from the oil, and I copied off this afternoon the result of their treatment of 100 barrels of crude oil. From these 100 barrels of crude oil they made 3 barrels of gasolene, 4 barrels of benzine, 15 barrels of kerosene, 8 barrels of heavy kerosene, 21 barrels of gas distillate, 10 barrels of light lubricating oil, 12 barrels of neutral oil, 6 barrels of heavy neutral oil, 5 barrels of reduced stock lubricating oil and 11 barrels of crude asphalt, with a loss of 5 barrels.

These different bitumens which I have read vary from 76° Beaumé for the gasolene down to 14 of the reduced stock, ranging pretty regularly.

The maltha, that spoken of as being treated here, is simply another stage of the transformation from the petroleum to the asphalt.

Asphalt has been made artifically by several chemists. Professor Day, of the Geological Survey, has made some several times by a com-

The President. bination of herrings and sawdust and pitch pine. By putting these in a retort and distilling them he succeeded in getting a product that, in appearance and in chemical action, was almost exactly like the Gilsonite; and Professor Engler, a German chemist, has succeeded in the same way in manufacturing asphalt from sawdust.

The asphaltina which the author spoke of is practically coal tar. It is a preparation of coal tar that has been patented for the purpose of making pavements, and within the last four or five years quite a number of pavements in New England and in New York State have been laid with this material, and they give very good results. You must know that the coal tar and asphalt are in the same family chemically, that the asphalt is considered a natural, while the coal tar is considered an artificial, bitumen.

Mr. Jackson. Mr. Jackson.—I understand that, in the case of the asphaltina, one is able to heat it to a very much higher temperature, and the claim of Mr. Just is that by so doing in the presence of sulphur he is able to take away any lack of saturation which may exist in the original product. If one attempted to treat asphalt itself by sulphurizing at a high temperature, the product would not be satisfactory, it would not stand the temperature. Inasmuch as coal tar will stand this sulphurization at a high temperature, the claim is made that asphaltina is a saturated product and much less liable to be acted upon by water.

The Authors. The Authors (communicated).—During the foregoing discussion the question was raised as to the action of strong brine upon asphalt. We have subjected three brands of asphalt to this action for nine months, with the results as shown in the following table:

	Distilled water.	Sea water.	Brine.
Trinidad	Very strong action.	Considerable action.	No action.
Bermudez	Slight action.	Very slight action.	No action.
Alcatraz	Slight action.	Very slight action.	No action.

It will be seen that sea water serves as a slight protection against the action of water upon asphalt, and that when asphalt is covered with brine absolutely no deterioration takes place. Beyond question, the reason for this lies in the fact, as before explained, that brine contains practically no oxygen in solution.

But besides the action of the dissolved oxygen, there is the question of the action of other gases which may be in solution in the water. The following table shows the relative action of various dissolved gases in water upon Trinidad refined asphalt during a period of six months:

The Authors.

Water boiled free from oxygen and tightly sealed in a jar	Very slight action.
Water with usual amount of oxygen	Slight action.
Water saturated with pure oxygen	Considerable action.
Water saturated with carbonic acid gas	Slight action.
Water saturated with sulphurous acid gas	Considerable action.
Water containing ammonia gas	Very strong action. Asphalt cracked and curled up, and almost all punk.

Compared with the following table it will be seen that ammonia acts much less strongly upon the other asphalts:

	Action.
Bermudez	Slight.
Alcatraz D	None.
“ XX	Very slight.
“ Maltha No. 1	Slight.
“ “ No. 2	Considerable.
Cuban	None.
Assyrian No. 2	Very slight.
“ No. 3	Slight.
“ No. 4	Very slight.
“ No. 6	None.
“ No. 7	Very slight.

The question as to whether bacteria have any effect in the deterioration of asphalt may be answered in the negative. Trinidad asphalt has been subjected to the action of sterilized and unsterilized samples of tap water, beef broth and also of urine for two months, with the result that the action was as strong in the sterilized as in the unsterilized samples.

Experiments have also been made upon the effect of temperature in the deterioration of asphalt by water. The table given below shows the results obtained on Trinidad asphalt:

Temperature.	Action in one week.	Action in six months.
15° C.	None.	Slight.
20° C.	Very slight.	Considerable.
37° C.	Slight.	Strong (nearly all punk).

These results point out a fact of practical importance. It will be seen that for cool climates and for temperatures up to ordinary room temperature the action of water on asphalt is not nearly as great as it is above that temperature, and that from room temperature to blood heat the deteriorating action of water on asphalt increases rapidly as the temperature rises.

BROOKLYN ENGINEERS' CLUB.*

No. 26.

MOUNT PROSPECT LABORATORY.

By George C. Whipple, Biologist and Director, Mem. B. E. C.

Presented April 12th, 1900.

The practical value of the sciences in our modern civilization is strikingly attested by the increase in the number of laboratories connected with various departments of nation, state and municipality. This is emphatically true in the domain of sanitary science, where the advances in chemistry, microscopy and bacteriology have wrought revolutionary changes. With the knowledge that many diseases are caused by living organisms, and that some of them are transmitted by water, came the need of more careful supervision of public water supplies, which resulted in the establishment of laboratories devoted to water analysis. The pioneer work of the Massachusetts State Board of Health has been followed by the installation of laboratories in most of our large American cities. In many instances these are operated in connection with the departments of health, but in Boston, Lynn, Louisville, Cincinnati, Pittsburg, Albany, Washington and elsewhere, laboratories have been organized in connection with the departments of water supply either for the purpose of experimental work or because the character of the water supply was such that proper management depended upon analytical as well as engineering data. Departments of water supply should be justly held responsible for the quality as well as the quantity of the water supplied to the public. This involves a constant knowledge of the sanitary condition of the water which can be obtained only by frequent analysis and inspection.

* This Club is not responsible, as a body, for the facts and opinions advanced in this publication.

The complicated character of the water supply of Brooklyn made the need of a laboratory apparent to the Department of Water Supply several years ago, but it was not until 1897 that an appropriation for the purpose was obtained. In May of that year the writer was appointed Biologist and Director of the Laboratory and instructed to prepare plans for the installation and equipment of a complete chemical and biological laboratory. Mount Prospect Reservoir, near the entrance to Prospect Park, was selected as the most available site, and the gate-house of the reservoir was found to have ample accommodations. Contracts were let during the summer and the laboratory was in complete operation on the first of October, though regular microscopical examinations of the water were begun early in July.

Mount Prospect Laboratory has a fortunate location. It is conveniently near the Long Island Railway Depot, where the samples from the water-shed are received, Ridgewood Reservoir, the chief distribution reservoir, and the office of the department at the Municipal Building. Its isolation and elevation make it comparatively free from noise and dust, while the building is well lighted by large windows, heated by hot water, provided with gas, electricity and telephone. The upper portion of the building contains three rooms, besides the keeper's office, and a corridor from which visitors may ascend to an observatory on the roof. The three rooms are known as the general laboratory, or preparation room, the biological laboratory, and the chemical laboratory. In the basement are the physical laboratory, the general store room and the furnace room. There is also a sub-basement suitable for bacteriological work during hot weather.

The general laboratory is devoted to the shipment of bottles and reception of samples, the washing of glassware, the sterilization of apparatus, the preparation of culture media, and to such chemical operations as might charge the air with ammonia and the fumes of strong acids. The room contains a well-ventilated hood; a work-table, under which are closets and drawers; a shipping desk; a large sink, with draining boards on the sides; a drying oven; a hot-air sterilizer; a steam sterilizer; an autoclav; an automatic still, and a distilled-water tank lined with block tin and having delivery tubes that extend to the other rooms. See Figures 1 to 7.

The Biological Laboratory is devoted to the bacteriological and microscopical examinations of water and to the study of the various

organisms found. It also forms the office of the director. It contains a work-table; a long work-shelf with three windows in front; three incubators; an ice-chest for the storage of culture media; a case for sterilized apparatus; a book-case, with a good working library; a desk; a typewriter; and cabinets for report blanks, biological specimens, etc. Electric bells connect with the different laboratories and with the telephone in the office of the keeper of the reservoir.

The Chemical Laboratory is the largest of the three rooms. Its atmosphere is kept free from ammonia and from the fumes of strong acids in order not to vitiate the results of the water analyses there carried on. It contains a table for holding the samples of water that are being analysed; three work-tables; two work-shelves with windows in front; a weighing-room, with balance in front of window and with a wide desiccator-shelf and a drying-closet; a hood, under which are two steam baths; a battery of twelve stills for ammonia distillations; a still for obtaining redistilled water; an apparatus for gas analysis; a battery of twelve Sedgwick-Rafter filters used in the microscopical examination of water; an apparatus case; a case for chemicals; a Richards pump; and various pieces of specially designed apparatus that facilitate the work of analysis. The room also contains a combustion furnace and a Mahler Bomb Calorimeter for the analysis of coal and the determination of its heating power. A storage room opens from the Chemical Laboratory and there is a small darkroom under the stairs. The three laboratories have marble-tiled floors, and the work-tables and shelves are covered with white tiles throughout. The partitions between the rooms are largely of glass.

The Physical Laboratory in the basement is not fully completed. At present it contains a crusher; a coal-sampler; sieves for sand-analysis; and a complete outfit for testing cement.

The laboratory force consists of one Biologist and Director, one Chemist, one Assistant Chemist, and three Assistants.

The work of the laboratory may be divided into three parts: Water Analyses, Miscellaneous Analyses, and Experimental Work.

Water Analyses.

The routine work consists of the regular examination of samples of water received from all parts of the water-shed and distribution system, *i. e.* from the driven wells, streams, ponds, aqueducts, reser-

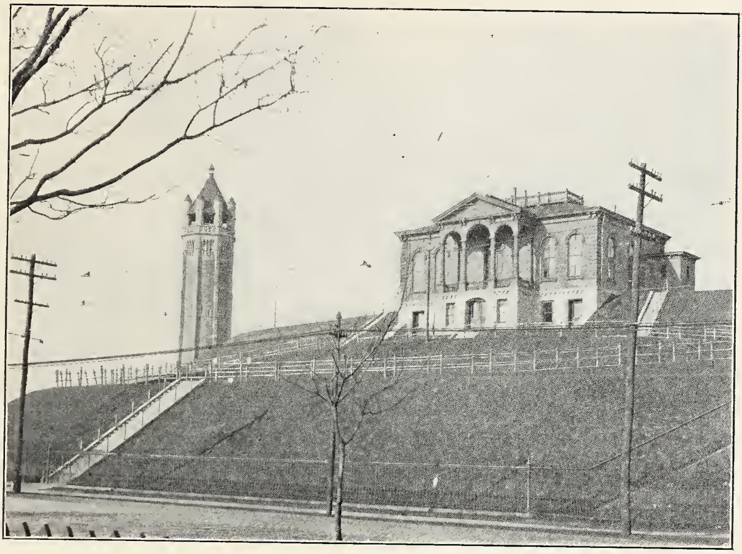


Fig. 1.—Mt. Prospect Laboratory. Exterior View.

Fig. 2.—Mt. Prospect Laboratory. Biological Room.

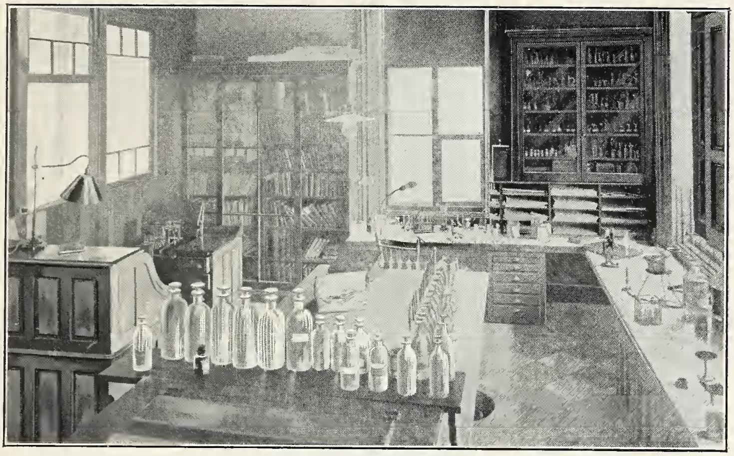


Fig. 3.—Mt. Prospect Laboratory. Biological Room.

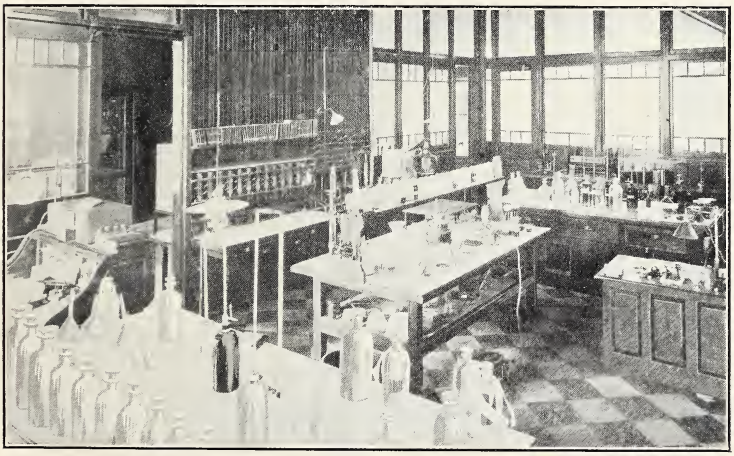


Fig. 4.—Mt. Prospect Laboratory. Chemical Room.

Fig. 5.—Mt. Prospect Laboratory. Chemical Room.

Fig. 6.—Mt. Prospect Laboratory. Chemical Room.

voirs and service taps. The complicated and varied character of the water supply requires the examination of an unusually large number of samples, and it is safe to say that no water supply in this country is examined more thoroughly and minutely than that of Brooklyn. The regular routine includes the bacteriological examination of three samples of water from the Ridgewood Pumping Stations and from a tap in the city collected daily; the complete physical, chemical and biological examination of nine samples from the distribution system collected weekly; the physical, biological, and partial chemical examination of twenty-four samples from the supply ponds collected weekly, with complete chemical analyses monthly; the complete examination of nineteen samples from driven wells collected monthly; and the complete examination of twenty-one samples from the private water supply companies of Brooklyn and from the water supplies of the Borough of Queens collected quarterly. In addition to these regular samples, many extra samples are taken at various times and places as occasion requires. During the two and a half years that the laboratory has been in operation this schedule has resulted in the analysis of more than six thousand samples, as follows:

Number of samples received from July 12, 1897, to April 1, 1900.	6 471
Number of physical examinations	5 025
Number of complete chemical analyses	2 562
Number of partial chemical analyses	1 049
Number of microscopical examinations	4 688
Number of bacteriological examinations	5 230
Number of tests for Bacillus coli communis	2 630

The samples of water from the water-shed are collected in the forenoon during the early part of each week and sent to the laboratory by express. The average time that elapses between the collection of a sample and the beginning of its analysis is about hours, but this time varies from ten minutes to eight hours. Samples are collected in large bottles for chemical analysis, and in small sterilized bottles for bacteriological examination. The large bottles have a capacity of 1 gall., are made of heavy, clear, white glass, and have glass "Hood" stoppers. They are not sterilized, but are carefully cleaned with chromic acid before leaving the laboratory. Brown paper is tied over the stoppers to prevent contamination from dust, and the bottles are packed in boxes that have separate compartments lined with indented fiber paper and that are provided with tight fitting covers. The breakage of bottles packed in this way is very small.

The bottles for the bacteria samples hold 2 oz., and are made of clear, white glass, and have wide mouths with glass stoppers. They are known to the trade as "Chemical salt-mouths." These bottles are sterilized each time before use. The stoppers of the bottles are covered with pieces of tin foil, and each bottle is then placed in a tin box just large enough to receive it and that has a screw cap. The tin boxes are painted to keep them from rusting. The bacteria samples are shipped in portable ice-boxes, sections of which are shown in Fig. 11. There is an outer box with asbestos packing and a copper lining, and an inner copper tray, divided into compartments to hold the tin boxes just mentioned, and between the outer box and the tray is a large space for ice. The box holds sufficient ice to last eight hours in hot weather, and the samples, almost invariably, are received in good condition.

The samples from the supply ponds are collected at a depth of 1 ft. below the surface. The shallowness of the ponds makes it unnecessary to collect samples at greater depths. The samples from the distribution reservoirs are collected just outside the gate-houses, where the flowing water gives a representative mixture of the water entering or leaving the reservoirs. Special precautions are taken to avoid contamination in the collection of samples and to this end special forms of collecting apparatus have been devised.

The apparatus for collecting the bacteria samples is shown in Fig. 8. The sterilized bottle is placed in a metal frame attached to the lower end of a small brass tube and is held in position by spring clips. A small rod extends through the brass tube and at the lower end is provided with a clutch for grasping the stopper of the bottle. By means of this rod the bottle may be opened and closed under water.

The apparatus used for collecting samples from beneath the surface, when necessary, is shown in Fig. 9. The frame consists of a brass wire, A, attached to a weight, B, with clips for holding the bottle, C. The frame is supported by the spring, F, joined to the sinking rope, E. A flexible cord, G, extends from the top of the spring to the stopper of the bottle. The length of this cord and the length and stiffness of the spring are so adjusted that when the apparatus is suspended in the water by the sinking-rope the cord will be just a little slack. In this condition it is lowered to the desired depth. A sudden jerk given to the rope stretches the spring and produces sufficient tension on the cord, G, to pull out the stopper.

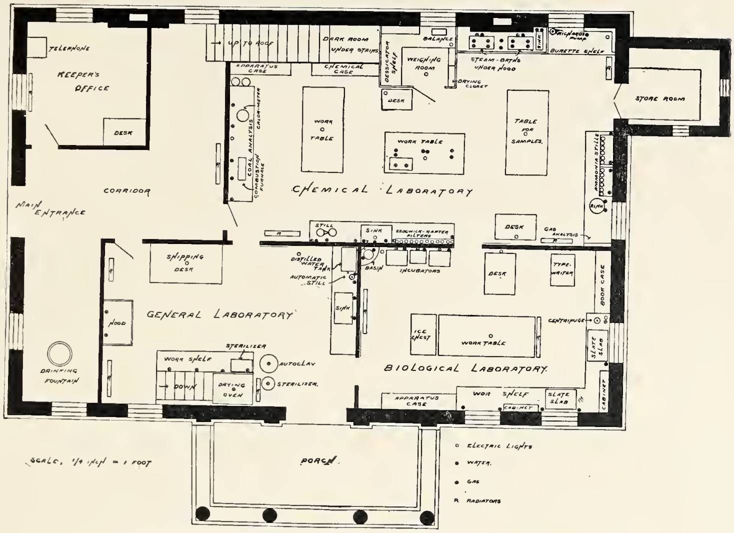


FIG. 7.—MT. PROSPECT LABORATORY. FLOOR PLAN.

APPARATUS FOR COLLECTING SAMPLES OF WATER.

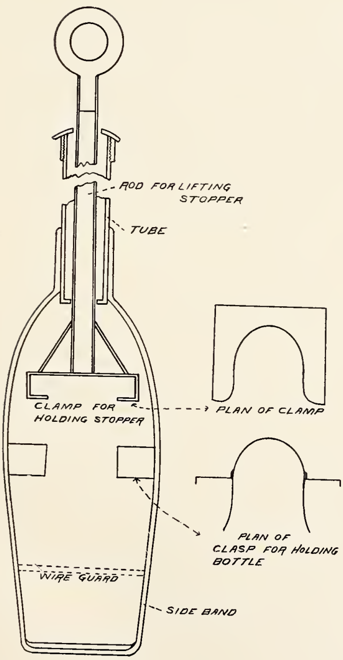


FIG. 8.—BOTTLE HOLDER FOR COLLECTING BACTERIA SAMPLES.

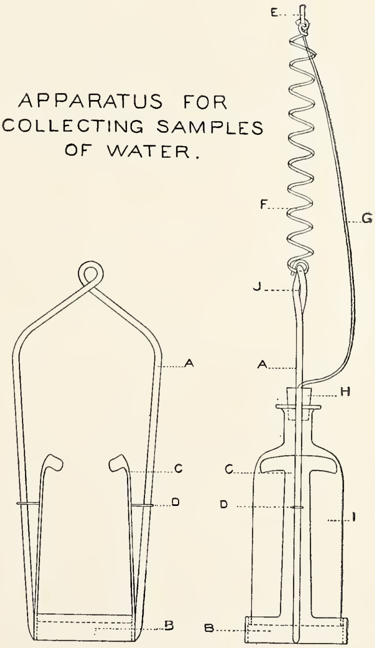


FIG. 9.—COLLECTING APPARATUS FOR SUB-SURFACE SAMPLES.

The apparatus for collecting bacteria samples from beneath the surface is similar in principle and is shown in Fig. 10. The bottle is replaced by a sterilized vacuum tube, with end turned outwards and backwards and drawn to a point. The pull of the cord breaks off the tip of the tube, and the pressure of the water causes the tube to fill. The end may be then sealed with an alcohol lamp or closed with a bit of sterilized wax. The frame for holding the tube consists of a short piece of lead pipe, which also serves as a weight.

The temperature of each sample is taken at the time of collection and recorded on a certificate, together with the locality of the sample, the date of collection, the name of the collector, etc. Temperature readings below the surface are obtained with the thermophone (Henry E. Warren and Geo. C. Whipple, "The Thermophone," *Technology Quarterly*, July, 1895).

When the samples reach the laboratory, each is given a serial number and entered in an index book, and throughout all the examinations each sample is known by its number rather than by the name of the locality from which it was collected.

It would be out of place in this paper to describe in detail all the methods used in the analysis of the samples, but inasmuch as methods differ considerably in different laboratories it seems desirable to give at least an outline of the methods used and to describe those that differ materially from those practised elsewhere.

Physical Examination.

The physical examination includes the observation of the temperature of the water, its general appearance, its turbidity, its color and its odor.

Temperature.—The temperature of the sample is observed at the time of collection as mentioned above.

Appearance.—The amount of sediment and the turbidity after standing twelve hours are estimated by inspection and recorded numerically according to the following scale:

Turbidity.	Sediment.
0. None.	0. None.
1. Very slight.	1. Very slight.
2. Slight.	2. Slight.
3. Distinct.	3. Considerable.
4. Decided.	4. Heavy.

Turbidity.—The actual turbidity is determined by comparison of the sample with silica standards of turbidity, as described by Whipple and Jackson in the *Technology Quarterly* for December, 1899, and September, 1900. According to these standards a turbidity of 100 is equal to that produced by adding 100 mg. of finely divided diatomaceous earth to 1 liter of water. Comparisons are made in gallon bottles or in Nessler jars, held towards the light or placed over a series of black lines.

Color.—The color is determined by comparison with the Platinum-Cobalt Standard, described by Hazen in the *American Chemical Journal*, Vol. XIV, page 300. The comparisons are made in 100 c. c. Nessler jars, 1 in. in diameter and 12 ins. long.

Odor.—The "cold odor" is observed after vigorously shaking the bottle in which the sample is contained. The "hot odor" is observed by heating about 200 c.c. of the sample in a beaker covered with a watch-glass to a point just short of boiling, and applying the nose as soon as the water has sufficiently cooled. The results are expressed according to the following scale of intensity, and with the following abbreviations:

Scale of intensity.	Abbreviations.
0. None.	v. Vegetable.
1. Very faint.	e. Earthy.
2. Faint.	a. Aromatic.
3. Distinct.	g. Grassy.
4. Decided.	f. Fishy.
	m. Moldy.
	etc., etc.

Chemical Analysis.

The sanitary chemical analysis ordinarily includes the determination of the nitrogen as albuminoid ammonia, free ammonia, nitrites and nitrates; total residue on evaporation; loss on ignition; chlorine; iron and hardeners. In addition to these the following determinations are sometimes made: Oxygen consumed; alkalinity; incrusting constituents; dissolved oxygen; carbonic acid, etc.

Form of Expression.—The results of the chemical analyses are expressed in parts per million.

Nitrogen as Albuminoid Ammonia.—The method of Wanklyn is used according to the practice of the Massachusetts State Board of Health, described in the two special reports on Water Supply and Sewerage

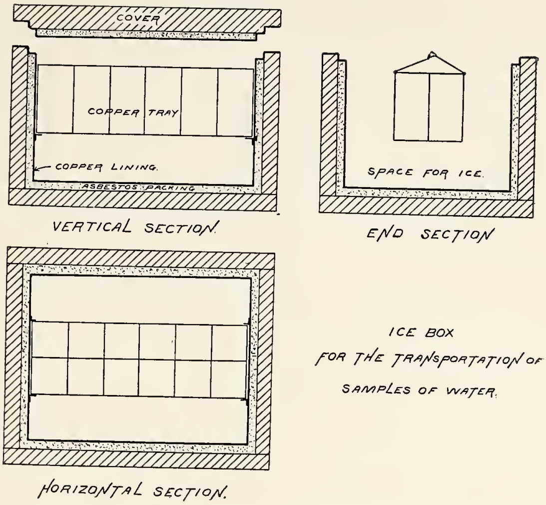


FIG. 11.—PORTABLE ICE-BOX FOR SHIPPING BACTERIA SAMPLES.

FIG. 10.—COLLECTING TUBE FOR SUB-SURFACE COLLECTION OF BACTERIA SAMPLES.

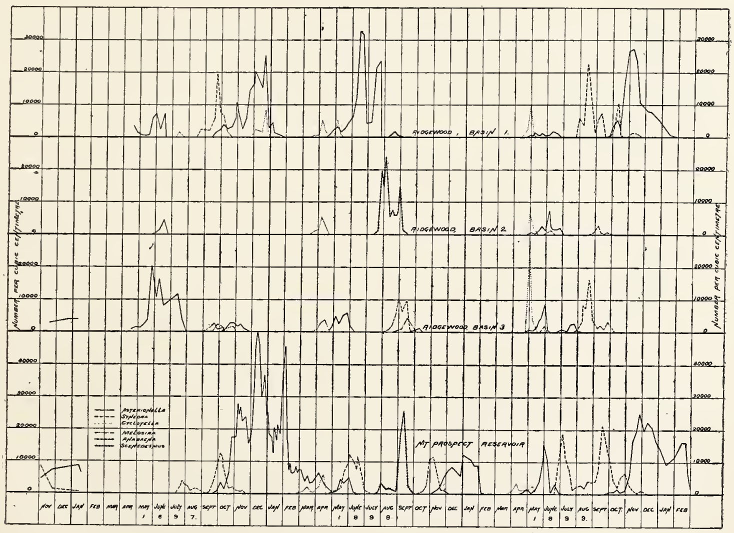


FIG. 12.—DIAGRAM SHOWING SEASONAL DISTRIBUTION OF VARIOUS ORGANISMS IN RIDGEWOOD AND MT. PROSPECT RESERVOIRS.

published in 1890. The total albuminoid ammonia is determined on the unfiltered water. The dissolved albuminoid ammonia is determined after filtering the sample through filter paper. The suspended albuminoid ammonia is found by subtracting the dissolved albuminoid ammonia from the total albuminoid ammonia. In the case of ground waters the total albuminoid ammonia only is determined. The form of distilling apparatus is practically the same as that designed by Mr. H. W. Clark, and used at the laboratory of the Massachusetts State Board of Health.

Nitrogen as Free Ammonia.—The free ammonia is determined by Wanklyn's method, referred to under albuminoid ammonia; 500 c.c. of the sample serves for the determination of both the free and albuminoid ammonia.

Nitrogen as Nitrites.—Warrington's modification of the Griess method is used.

Nitrogen as Nitrates. —The phenolsulphonic acid method of Grandval and Lajoux is used, but with certain modifications tending to refinement. The quantities operated upon vary from 2 c.c. to 50 c.c. according to the amount of nitrogen present as nitrates. Permanent standards are used instead of preparing fresh standards for every set of comparisons. Comparisons are made in 100 c.c. Nessler jars.

Residue on Evaporation.—For the determination of the residue on evaporation 200 c.c. of the sample are evaporated to dryness on a water bath in a platinum dish of known weight, dried for half an hour in a steam oven, cooled in a desiccator, and weighed. Where it is necessary to determine the amount of suspended matter the residue is determined, both before and after filtering the sample through a Pasteur filter, and the difference obtained.

Loss on Ignition.—After the determination of the total residue on evaporation the platinum dish is placed in a larger platinum dish that serves as a radiator, ignited for seven minutes at a low red heat, treated with a small amount of distilled water to restore any loss of water of crystallization that may have been driven off by the ignition, evaporated to dryness on the water bath, and dried, cooled and weighed as before. The difference of weight before and after ignition gives the loss on ignition. The loss on ignition is not determined for the ground waters or for the waters of the distribution system.

Chlorine.—The chlorine is determined by titration with silver nitrate, using potassium chromate as an indicator, according to Hazen's modification of Mohr's method described in the *American Chemical Journal*, Vol. XI, page 409.

Hardness.—The hardness is determined by Clark's Soap Method, substantially as described in Sutton's Volumetric Analysis, but with certain modifications in the preparation of the soap solution. No attempt is made to separate the "temporary hardness" from the "permanent hardness" by the method of boiling. The information covered by these terms is obtained when necessary by the determination of the alkalinity and the incrusting constituents.

Alkalinity.—The alkalinity of a water is a measure of the carbonates and bicarbonates present. It is ordinarily determined by titrating 100 c.c., of the sample with $\frac{n}{50}H_2SO_4$, using methyl orange as an indicator; but it is sometimes desirable to substitute erythrosine or lacmoid for methyl-orange as an indicator, making the titration after heating the sample to the boiling point. It has been found that when the true end-points are known and the proper corrections for the indicators are applied, all of these indicators give practically the same results. They differ in their power of showing the presence of sulphate of alumina, and meythl orange should not be used in determining the alkalinity of a water that has been treated with that coagulant.

Incrusting Constituents.—The incrusting constituents are the salts that give to water its "permanent hardness" The determination is made according to Hehner's method as described by Leffman in his "Examination of Water." The sum of the alkalinity and incrusting constituents is approximately equal to the hardness as determined by the Soap method.

Iron.—The iron is determined from the residue in the platinum dish according to Thompson's Method as described in Sutton's Volumetric Analysis, but with certain changes in technique that tend to greater accuracy.

Oxygen Consumed.—The Kubel Method is used substantially as described in the special reports of the Massachusetts State Board of Health above referred to. The period of boiling is five minutes.

This determination is seldom made on the regular samples.

Dissolved Oxygen.—Winkler's method is used according to the modi-

fications of Drown and Hazen described in the special reports of the Massachusetts State Board of Health above referred to.

Carbonic Acid.—For the determination of the "free" and half-bound carbonic acid, Pettenkofer's method is used according to the modifications of Trillich described in Ohlmüller's "Untersuchung des Wassers," edition of 1896. The free carbonic acid is determined on the fresh sample by titrating with $\frac{n}{22}$ Na_2CO_3, using phenolphythalene as the indicator. It is also obtained differentially by the application of Pettenkofer's method before and after passing the sample through a tube containing small gravel stones with a current of air drawn in the opposite direction.

Permanent Standards.—For the determination of free and albuminoid ammonia, nitrites, nitrates, iron, color, and turbidity, permanent standards are used as described by D. D. Jackson in the *Technology Quarterly* for December, 1900.

Microscopical Examination.

The microscopical examination of water determines the number and kind of microscopic organisms present.

The Sedgwick-Rafter method is used with the modifications described in the author's "Microscopy of Drinking Water." The results are expressed in number of standard units of organisms per cubic centimeter. The amount of amorphous matter is expressed in terms of the same unit.

Bacteriological Examination.

The bacteriological examinations consists of the determination of the number of bacteria present in a sample of water, and tests for the presence of Bacillus coli communis. No general qualitative work is undertaken in connection with the regular routine.

Quantitative Examination.—One cubic centimeter of the sample (diluted $\frac{1}{10}$, or $\frac{1}{100}$, if necessary), is mixed with 5 c. c. of sterilized nutrient gelatine in a Petri dish and allowed to cool on a level surface. When hard, the culture is placed in an incubator and kept at a temperature of 20° C. in an atmosphere saturated with moisture for 48 hours, after which the number of colonies is counted. It is then returned to the incubator and kept 24 hours longer, after which a second count is made. The 72-hour count is the one reported. All determinations

are made in duplicate. The gelatine used as the culture medium is prepared substantially as recommended in the report of the Bacteriological Committee of the American Public Health Association, published in 1898. It is given an acidity of 1.5 per cent.

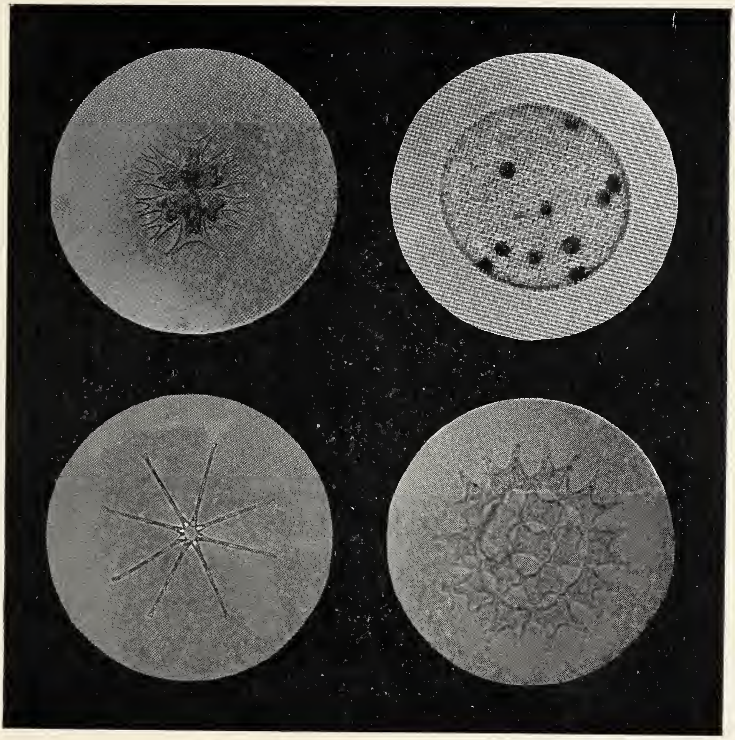
Tests for Bacillus Coli Communis.—Smith's fermentation method is used as the basis of the test, isolation of the colon bacillus being attempted only when a positive test is obtained in the fermentation tube. If the amount of gas in the fermentation tube after 48 hours' incubation at 37° C. is above 30% and below 70% of the closed arm, a portion of the sediment is plated on lactose-litmus-agar. If red colonies develop after 12 hours' incubation, transfers are made from them to glucose gelatine, milk, nitrate solution, sugar-free broth (for indol), and glucose broth in a fermentation tube. If these tests give positive results, the presence of the colon bacillus is considered as proven.

It is not within the province of this paper to discuss the quality of the water supply of Brooklyn—that belongs more properly to the annual reports of the Department of Water Supply—but an account of the growths of microscopic organisms in the supply may be of general scientific interest.

Microscopic Organisms.

The troubles of the Brooklyn water supply during the past few years have been occasioned by the growth of odor-producing organisms in the distribution reservoirs. The growth of Asterionella in Ridgewood and Mt. Prospect Reservoirs and its effect upon the quality of the water have been so fully described (Report of Dr. Albert R. Leeds to the Department of City Works, Division of Water Supply, Brooklyn, 1897), that it is not necessary to again relate the details of its occurrence. That the growths of Asterionella continue to occur periodically is shown by the profiles on Fig. 12. See also Figs. 13 and 14.

Asterionella is not the only odor-producing organism that develops in the distribution reservoirs. Anabæna, Synedra, Cyclotella and other forms are sometimes present in great abundance. The character of the water collected from the water-shed of the Brooklyn supply is such as to furnish abundant nourishment for microscopic plant life and organisms that in many water supplies appear in small numbers without having any noticeable effect on the character of the water develop in Brooklyn to an enormous extent.



Micrasterias, × 200. *Volvox*, × 50.

Asterionella, × 250. *Pediastrum*, × 250.

Fig. 13.—Photomicrographs of Organisms.

This is emphatically true in the case of Synedra pulchella, a diatom that until recently has not been classed as an odor-producing organism. Like Asterionella, this diatom contains oil globules, but the oily substance has not the same strong odor as the oil of Asterionella. Nevertheless, Synedra is capable of imparting an odor to water if present in sufficient numbers. The odor is not a characteristic one like that of Asterionella, Uroglena, Dinobryon, etc., and can be described by no more exact term than "vegetable." The taste imparted to water by Synedra is perhaps more noticeable than the odor, being somewhat "earthy" as well as "vegetable."

In few water supplies in this country is Synedra pulchella ever present in numbers greater than 5 000 per cubic centimeter, and although a smaller number than this will make a water turbid, it requires about this number to produce a noticeable odor. In Brooklyn, however, the growths of Synedra have been much heavier, as may be seen from Fig. 5. On several occasions the numbers have reached 15 000 per cubic centimeter, and once as many as 20 000 per cubic centimeter were observed. The water at such times has been very turbid, and has had the vegetable and earthy taste and odor just referred to.

The seasonal distribution of Synedra in the Brooklyn reservoirs is worth noting. In Mt. Prospect Reservoir it has appeared regularly in the spring and fall, according to the usual mode of occurrence of the diatoms, but it has always appeared after the Asterionella growths in the spring and before the Asterionella growths in the fall. In Ridgewood its occurrence has been more variable. In 1899 there were heavy growths in Basins 1 and 3 during the month of August.

Cyclotella is another diatom that, because of its limited occurrence, has been seldom known to cause trouble in water supplies. Yet in Ridgewood Reservoir it is sometimes present in large numbers. Its growth has been usually of short duration, but when present in numbers equal to 5 000 standard units per cubic centimeter, its aromatic odor could be distinctly recognized.

Two species of Melosira occur in the Brooklyn supply. Melosira granulata, the common free-floating form, is seldom present in sufficient numbers to cause trouble, though two or three thousand per cubic centimeter are sometimes found. Melosira varians grows luxuriantly on the shores of Ridgewood Reservoir, and constant scraping is

required during the summer to keep the banks clean. During severe storms the filaments of Melosira become detached from the shores and are scattered through the water, and on one occasion the amount of vegetable matter so detached was sufficient to impart a distinct taste to the water. Like Synedra pulchella, Melosira produces simply a vegetable, earthy and somewhat oily taste and odor, very different from the aromatic, fishy odor of Asterionella and Cyclotella.

Next to Asterionella, Anabæna has probably caused more trouble in the Brooklyn water supply than any other organism. During the past two years it has appeared but once, but there are good reasons to believe that in the summer of 1896, prior to the investigations of Dr. Leeds, the disagreeable odor of the tap water was due not so much to Asterionella as to Anabæna.

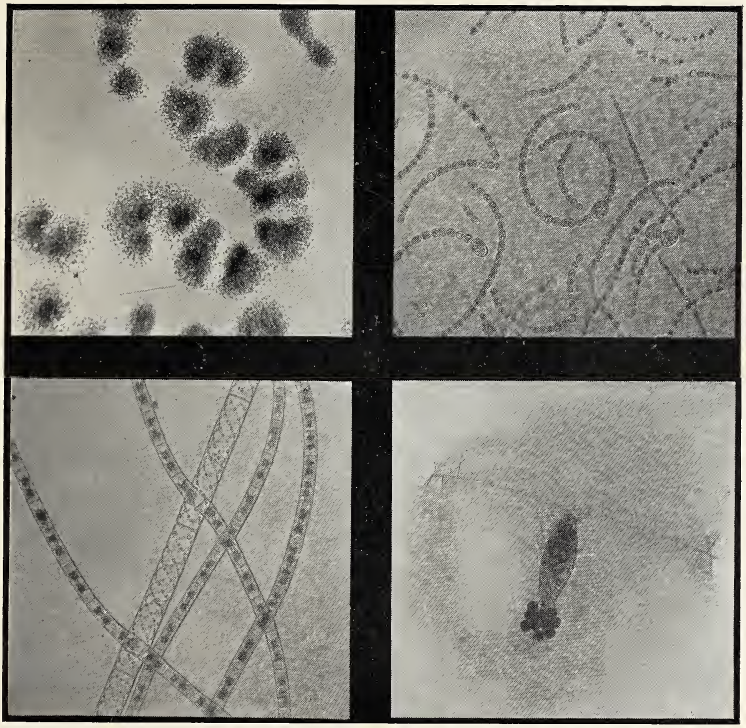
In July, 1898, Anabæna appeared in all the Ridgewood basins. In Basin 3 it did not develop to any extent. In Basin 1 it attained a maximum growth of 1 720 standard units per cubic centimeter on August 19th, and gave to the water its characteristic odor of moldy grass. In Basin 2, however, it developed to an enormous extent. On August 3d there were 24 000 standard units per cubic centimeter. From the last of July until early in September the water in the basin was densely turbid and had a green color. On quiet days a scum collected on the surface and drifted about with the wind. The water was entirely unfit for use and the gates of the reservoir were kept closed. As soon as the organisms disappeared in the fall and the water had again assumed its normal condition, Basin 2 was emptied and cleaned, with the hope of preventing recurrence of such growths in the future. An examination of the deposit at the bottom of the reservoir showed that it was well seeded with the spores of Anabæna. Since that time there has been no further development of this organism.

In September, 1898, a phenomenally large growth of Scenedesmus occurred in Mount Prospect Reservoir, the water at one time containing 25 800 standard units per cubic centimeters. This organism in the numbers orinarily found causes no odor, but on this occasion the water had a distinct vegetable and aromatic odor and taste. The growth continued for several weeks.

There are several other organisms that deserve mention, because they occur in larger numbers in the Brooklyn water than in most water supplies. Dictyosphærium, Eudorina, Pandorina and Volvox are often

Photogravure Bormay & Co. N.Y.

A. Caldwell



Clathrocystis, × 250. *Anabœna*, × 250.

Spirogyra and Zygnema, × 50. *Diaptomus*, × 20.

FIG. 14.—PHOTOMICROGRAPHS OF ORGANISMS.

present in numbers of 500 standard units per cubic centimeters. Clathrocystis is not often found in Ridgewood Reservoir, but in Mount Prospect Reservoir it has been as high as 1 440 standard units per cubic centimeter. As a rule, the Brooklyn water contains comparatively few Protozoa, but Mallomonas has been observed as high as 660 per cubic centimeter in Ridgewood Reservoir, and Cryptomonas has been as high as 2 000 per cubic centimeter in Mount Prospect Reservoir. Chlamydomonas has been found occasionally.

To the water consumers of Brooklyn, however, the important fact is not the number of organisms in the distribution reservoirs, but the number present in the tap water in the city. Prior to the construction of the by-pass at Ridgewood the organisms that developed in the reservoir found their way, as a matter of course, to the service taps of the consumers. But by using the by-pass it has been found possible to so regulate the distribution of the water that very few organisms reach the consumers. Guided by the frequent and regular microscopical examinations made at Mount Prospect Laboratory the engineer has directed one or more basins to be isolated whenever it was found that odor-producing organisms were developing in them, the water, meanwhile, being delivered through the by-pass directly from the force mains to the distribution pipes. It has been found possible also to isolate Mount Prospect Reservoir and pump directly into the pipes. when growths of organisms made it seem advisable. The beneficial effect of this management can be illustrated by the following comparison.

At the time when Dr. Leeds made his report on the condition of the water, *i. e.*, from November, 1896, to February, 1897, Asterionella was present in the distribution system as follows:

	Number of Asterionella per cubic centimeter.
Ridgewood Reservoir, Basin 1	3 to 48
Ridgewood Reservoir, Basin 2	2 " 10
Ridgewood Reservoir, Basin 3	2 608 " 4 648
Mt. Prospect Reservoir	4 808 " 8 640
Tap supplied from Ridgewood, Basins 1 and 2	3 " 81
Tap supplied from Ridgewood, Basin 3	1 240 " 8 800
Tap supplied from Mt. Prospect Reservoir	2 400 " 7 460

During November and December, 1899, the corresponding figures were as follows:

	Number of Asterionella per cubic centimeter.
Ridgewood Reservoir, Basin 1	5 600 to 27 280
Ridgewood Reservoir, Basin 2	0 " 8
Ridgewood Reservoir, Basin 3	0 " 16
Mt. Prospect Reservoir	6 512 " 24 960
Tap ordinarily supplied from Ridgewood, Basins 1 and 2	0
Taps supplied from Ridgewood, Basin 3	0 " 16
Tap ordinarily supplied from Mt. Prospect Reservoir	8 " 56

During the period from November, 1896, to February, 1897, the water supplied to the city from Basin 3 and from Mt. Prospect Reservoir, had a very disagreeable taste and odor due to the presence of Asterionella, but during November and December, 1899, the water in the city had no odor due to Asterionella, even though this organism was far more abundant in Ridgewood and Mt. Prospect Reservoirs, than it had been during the winter of 1896–7. This freedom of the tap water from Asterionella was due to the use of the by-pass, the sections of the city that are ordinarily supplied from Ridgewood Basins 1 and 2, and from Mt. Prospect Reservoir, being supplied with water direct from the Ridgewood force mains.

Miscellaneous Work.

The miscellaneous work of the laboratory includes analyses of coal, lubricating oil, boiler scales, boiler compounds, cements, deposits from driven wells, etc. These are all problems of engineering chemistry and need not be described at length. The most important part of this work at the present time is the analysis of coal, and a brief description of the methods used may be of interest to some of the members of the Club.

The specifications under which coal is purchased by the department, require that each bid shall be accompanied by a sample of the coal offered, and provide that no bid shall be accepted unless the sample contains a certain number of heat units. Bituminous coals must contain not less than 13 500 B. T. U. per pound, and Anthracite coals not less than 12 500 per pound, the calculations to be made in both

cases on dry coal by the method of ultimate analysis. The amount of sulphur must not exceed 1 per cent. The specifications also provide that "if at any time the quality of the coal should prove inferior in any respect to that stipulated in the bid, * * * or if on analysis the quality is found to be of a lower standard than that of the sample furnished with the bid, the commissioner shall deduct such sum or sums from the estimated amount of money which would otherwise be due to the contractor, as he may deem to fairly represent the loss caused to the party of the first part by reason of the said depreciation in quality; and that in case of failure to comply with any of the other terms of this contract after due notice shall have been given to the contractor of such failure, the commissioner shall have the right to cancel the contract."

The samples of coal that accompany bids are analyzed by the method of ultimate analysis, and are also tested in the Mahler bomb calorimeter; but in the case of samples taken from each consignment, the ash is determined in the combustion furnace, and the heating power in the calorimeter.

The method of ultimate analysis was described by Mr. D. D. Jackson, chemist of the laboratory, at one of the library talks of the club in 1898. The sample of coal, usually about 10 lbs., is reduced by successive divisions to a small representative sample, which is powdered to such a degree of fineness that it will pass a sieve that has 60 meshes to the inch. The moisture is determined by ascertaining the loss in weight when dried for one hour at 110° C. This determination is made not for the purpose of obtaining the moisture in the coal as used, but in order that the results of the analysis may be calculated on the basis of dry coal. The amounts of carbon, hydrogen and ash are determined in a combustion furnace in the usual manner. The nitrogen is sometimes determined by the Kjeldahl method, but the determination is omitted on the regular work. The sulphur is determined by Eschka's method. The volatile sulphur, when required, is determined from the water left in the bomb of the calorimeter after the combustion. The oxygen is determined by difference. All of the determinations of the ultimate analysis are made in duplicate.

The heating power is calculated from the ultimate analysis according to the following formula:

$$\left.\begin{array}{r}\text{Number of B. T. U.}\\ \text{per pound of coal}\end{array}\right\} = 14\,544\ C + 62\,032\left(H - \frac{O+N}{8}\right) + 4\,500\ S,$$

where C, H, O, N and S represent the percentages of carbon, hydrogen, oxygen, nitrogen and sulphur.

Expressed in terms of calories, this formula becomes

$$H = 8\,080\ C + 34\,462\ \left(H - \frac{O + N}{8}\right) + 2\,500\ S.$$

The heating power of the coal is determined directly by combustion in the Mahler bomb calorimeter. A good description of this apparatus may be found in Gill's "Gas and Fuel Analysis for Engineers." About 1 gram of the powdered coal is weighed out in a shallow platinum pan and placed in the steel bomb of the calorimeter, after which oxygen is admitted until the pressure in the bomb reaches 25 atmospheres. The bomb is then immersed in the water cylinder and the charge ignited by means of an electric current, which is passed through a fine iron wire imbedded in the coal. The heat produced by the combustion of the coal causes an increase in the temperature of the surrounding water, and from the observed rise in temperature the heating power of the coal is calculated.

An examination of the results of about fifty analyses made by the method of ultimate analysis, shows that duplicate samples usually differ by about 1%, or approximately 150 B. T. U., while with the calorimeter duplicate usually agree within 50 B. T. U. Comparisons of determinations of heating power made by direct determination and by calculation from the ultimate analysis show an average difference of about 200 B. T. U.

Experimental Work.

Most of the experimental work that has been carried on in the laboratory has been in connection with problems pertaining to the condition of the water supply; but in addition to this, considerable attention has been given to the study of methods of water analysis and to other subjects of scientific interest. For the most part, these investigations have been of more interest to chemists and biologists than to engineers, but an account of the preparation of a map of the normal chlorine of Long Island may be appropriately presented to this Club. The following account is abstracted from a paper written by the author in collaboration with Mr. D. D. Jackson and read before the American Chemical Society on March 9, 1900.

It is well known that the amount of chlorine that a sample of water contains is of little value as an indicator of pollution except when compared with the normal of the region from which the sample was collected. By the "normal chlorine" is meant the amount of chlorine present in the unpolluted water of any particular locality. Except in regions where there are natural deposits of salt, it is dependent chiefly upon its distance from the sea-coast and upon the amount of exposure to ocean winds.

At the very outset of the work of Mt. Prospect Laboratory it was thought wise to ascertain the normal chlorine for the water-shed of the Brooklyn Water Supply, and as population had already encroached to a considerable extent upon its western portion, it was decided to extend the observations to the entire island. There were two reasons why this seemed desirable: First, it was believed that the isochlors would be found to be approximately parallel to the shore line, and that the more exact location of the isochlors to be obtained in the sparsely settled regions would be of assistance in extending the lines over the water-shed of the Brooklyn supply. Second, in the event of an eastward extension of the supply, the isochlors would be of value in estimating future pollution.

Accordingly, in October, 1897, a collector was sent over the island to secure samples from ponds, streams and wells that showed no evidences of pollution. Bottles were sent to him at various stations on the Long Island Railroad, and from these places as centers, local trips were made by carriage and by bicycle. The general plan of collection was to obtain several series of samples in north and south lines across the island and a few scattered samples at the eastern extremity. In April, 1898, the collector made a second trip over the island and secured duplicate samples from some of the localities first visited, besides samples from some new regions. In these two trips samples were collected from seventy-seven sources and a few more were subsequently added. Many of these, however, had to be discarded, as they were evidently not normal. In certain places the only samples that could be obtained were from wells, and some of these were so near to houses and barns that contamination was apparent. Moreover, there were some regions near the center of the island where, during the October trip, the collector was unable to find any water at all, because of the sandy nature of the soil.

The following is a list of the samples that were apparently normal in their chlorine contents and that were used in the preparation of the map of normal chlorine for the island, shown in Fig. 15.

Number of Sample.	Chlorine.	Sample.	Locality.
1..........	15.8	Well.	$\frac{1}{4}$ mile east of Montauk Station.
2..........	16.5	Well.	Amagansett, 200 ft. south of depot.
3..........	30.8	Well.	Bridgehampton, $1\frac{1}{2}$ miles southeast of station, and 1 mile north of beach.
5..........	17.2	Spring.	$1\frac{1}{2}$ miles southwest of Sag Harbor.
6..........	61.8	Well.	1 mile north of Greenport.
8..........	12.9	Pond.	Mattituck.
9..........	16.4	Well.	Aquebogue.
10..........	7.6	Stream.	Peconic River, $\frac{1}{2}$ mile north of Manor.
11..........	6.4	Well.	1 mile north of Manor.
13..........	6.0	Pond.	Long Pond.
14..........	10.0	Spring.	Wading River.
16..........	4.9	Well.	$1\frac{1}{2}$ miles south of Manor.
17..........	7.4	Well.	$3\frac{1}{2}$ miles north of Moriches.
18..........	7.4	Well.	$\frac{1}{8}$ mile north of Moriches.
19..........	6.1	Well.	1 mile northeast of Patchogue.
20..........	4.6	Pond.	2 miles north of Patchogue.
21..........	5.1	Well.	Medford Station.
23..........	6.7	Stream.	Scudder Brook, 1 mile northeast of Greenlawn.
26..........	4.8	Well.	4 miles north of Deer Park.
27..........	4.2	Well.	2 miles north of Deer Park.
29..........	5.0	Stream.	Brook at Belmont Pond, 2 miles north of Babylon.
30..........	4.6	Stream.	3 miles north of Babylon.
31..........	4.9	Stream.	Sampawanis Brook, $1\frac{1}{2}$ miles northeast of Babylon.
32..........	5.0	Well.	$1\frac{3}{4}$ mile north of Babylon.
33..........	5.1	Pond.	1 mile northwest of Babylon.
37..........	3.0	Well.	$\frac{1}{2}$ mile northeast of Hempstead.
43..........	7.0	Stream.	Kings Park, near State Hospital.
44..........	7.8	Pond.	Kings Park, near State Hospital.
45..........	5.2	Well.	$1\frac{1}{2}$ miles east of Selden.
48..........	6.0	Well.	1 mile northeast of Islip.
49..........	4.1	Stream.	Beaver Brook, $1\frac{1}{2}$ miles north of Islip.
50..........	4.0	Well.	1 mile south of Islip.
51..........	4.0	Well.	$\frac{1}{2}$ mile north of Center Islip.
55..........	4.2	Stream.	3 miles south of Smithtown.
60..........	7.0	Stream.	1 mile southeast of Huntington.
67..........	4.2	Well.	Melville Station.
68..........	4.2	Well.	$\frac{1}{2}$ mile south of Melville.
69..........	4.7	Well.	$1\frac{1}{2}$ miles southeast of Melville.
70..........	9.4	Well.	$\frac{1}{4}$ mile south of Massapequa.
78..........	4.0	Stream.	Upper end of Massapequa Stream.
79..........	4.8	Stream.	Upper end of East Meadow Stream.
80..........	3.8	Stream.	Hempstead Stream, above Hempstead.

The map shows that, except at the eastern end of the island and except near the coast, the normal chlorine is below 6 parts per million. On the south shore the isochlor of 6 parts per million is only 2 or 3 miles inland, while on the north shore it is probably 3 or 4 miles inland. The isochlor of 5 parts per million is about 2 miles further inland, and is substantially parallel with the former. The isochlor of 4 parts per million surrounds a narrow strip in the center of the island from 3 to 5 miles wide. In this region it is probable that the normal chlorine is even lower than 4 parts per

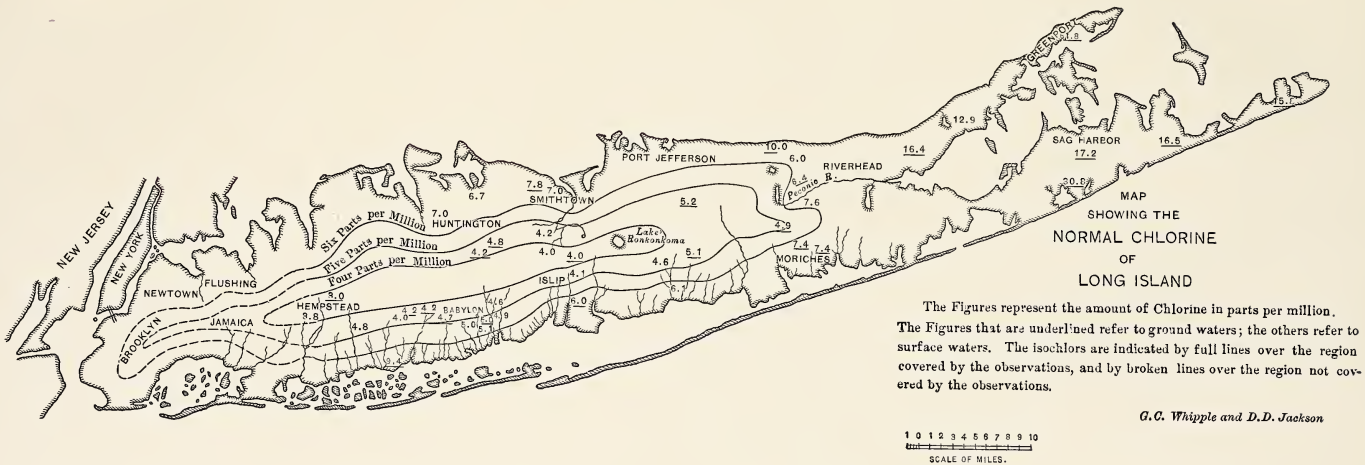


FIG. 15.—DISTRIBUTION OF NORMAL CHLORINE IN WATER OF LONG ISLAND, N. Y.

million. The normal chlorine at the line of the aqueduct of the Brooklyn water supply, which is almost parallel with the southern shore, is about 6 parts per million, but most of the streams that supply the ponds extend northward into the region where the normal chlorine is below 4 parts per million. It seems probable that the normal for the supply ponds is between 5 and 6 parts per million, and it may be assumed that any chlorine in these ponds in excess of 6 parts per million is due to the population dwelling upon the watershed.

In conclusion, the author wishes to express his thanks to Mr. Robert Van Buren, Engineer-in-charge, Department of Water Supply, Brooklyn, for permission to quote from unpublished laboratory records, and to Mr. I. M. De Varona, Engineer of Water Supply, under whose general direction the laboratory was established and the system of work inaugurated. The photographs of the laboratory that accompany this article were taken and kindly furnished by Mr. P. Schuyler Miller, the Assistant Chemist in the laboratory. The pictures of the organisms are copies from photomicrographs made by the author at the Biological Laboratory of the Boston Water Works under the direction of Mr. Desmond FitzGerald, C. E.

DISCUSSION.

The President. THE PRESIDENT.—The subject now comes up for general discussion, and we have quite a number of people here who are conversant with it, and we will be glad to hear from any of them.

Mr. Fuller. MR. FULLER.—I have listened with great pleasure to this paper. I think that it is certainly a matter of great congratulation to the Borough of Brooklyn that it has here a laboratory so well equipped and so well manned as is the one at Mount Prospect. The work which that laboratory is doing has been outlined by Mr. Whipple, who has brought out in general terms the work which is undoubtedly of very great value in the management of the water-works here. It is a matter which I have sometimes regretted that the results of his work were not made available to the profession. So far as I know that is not so.

The question of eliminating these organisms which produce disagreeable tastes and odors in the water by the use of every known expedient at the command of engineers is a matter which to my mind makes the cost of such a laboratory a thing of comparative insignificance.

The last generation has seen a very marked change in the laboratory and engineering work in general in connection with water supply questions. In 1868 the first laboratory was established in London, and used officially in connection with the water supply. That is to say, the government from that time on had direct supervision and control in a general way as to the character of the water shown by chemical analysis. That was thirty-two years ago, and I think it is just half that period, since 1884, that biological analysis has become prominent at all, and only during the last decade has it reached a degree of prominence that has attracted wide attention on the part of engineers and others interested in water supply questions.

The question of combining a water-works laboratory with work of an analytical nature connected with other lines of engineering is one which seems to have been brought out very clearly by the desire on the part of engineers and those possessing the information which comes from actual practice and observations in the field, combined with information of an analytical nature. At Louisville and Cincinnati that feature has come out very prominently, as Mr. Whipple has spoken of here in Brooklyn, in connection with analysis of coal and other materials. At Louisville, I remember that the laboratory had been established but a short time when it was found that a year's supply of cylinder oil that had been purchased for the pumping engine did not work satisfactorily, although the specifications had apparently been complied with under which the Water Department had been purchasing oil for some years. It was turned over to the laboratory for investigation, and after considerable study it was found possible, at comparatively

small expense, to add certain properties which made the oil thoroughly satisfactory, and from that time on practically all the supplies of importance used in connection with the water department were purchased under specifications providing for certain analytical standards, which was particularly the case in connection with the coal and the oils. Mr. Fuller.

At Cincinnati there was an independent water department managing the plant, and during the year and a half that I was there, there was quite a pile of work done in connection with various materials, stone, etc., which we used in masonry construction going on at that time, and since the experimental station was closed, the laboratory has been continued exclusively for examinations, chemical and physical, of the various materials used in the construction of that work.

At Pittsburgh I understand the same procedure is being followed in a measure, perhaps to a greater degree than at Cincinnati, and further than that, as I understand it, the laboratory was used during the experimental work there.

The Mount Prospect laboratory, I think, is universally regarded as perhaps the best equipped laboratory in the country, if not in the world. It is not the largest laboratory, but its equipment is the most admirable, and, speaking for the men interested in this line of work, I believe I can vouch for the very high regard that work coming from the Mount Prospect Laboratory is held. It is a matter of congratulation to the Borough of Brooklyn that they should have their water supply under the supervision of such an admirably equipped laboratory.

Mr. Allen Hazen.—I do not know that I have anything to say, Mr. President, except to express my admiration for the work which has been done in Brooklyn, and for the way it has been done. These questions of the qualities of water supplies are coming up very often, and the best that we can do is to get samples and have them sent somewhere for analysis. That procedure is almost always unsatisfactory, oftentimes it is entirely inadequate. The procedure adopted in this case of establishing a laboratory directly in connection with the waterworks is very much more satisfactory in every way, and, I think, should be adopted wherever the magnitude of the interests will justify it. Mr. Hazen.

I have had the pleasure of having something to do with establishing several such laboratories on a smaller scale, and the results have been most gratifying in every case. I think that as time goes on the number of these laboratories will be increased in various parts of the country.

The problems are so different on different water supplies that there isn't as much duplication in the work as would be at first supposed. In fact the problems are entirely local ones.

Mr. Baker.—I simply endorse what has been said by the two speakers who immediately preceded me, to the effect that the Club and the profession, generally, are to be congratulated for the presentation of this paper. Mr. Baker.

Mr. Baker. There have been a number of water-works laboratories in operation which have been doing a great deal of good work, and it is rather unfortunate that so little has been done to bring them before the attention of the public. It seems to me that this presentation to-night, and the publicity that will be given to the Brooklyn laboratory by the publication of the paper in your *Proceedings*, lead us to hope to see even more activity in this line of work than there has been in the past.

We have in round numbers about 3 500 water-works in the United States and Canada. Now the work which at present these various laboratories are able to do, has been brought out in a very interesting manner by the paper and the two speakers who have preceded me. You heard instances mentioned here to-night of laboratories started primarily for the study of water which are reaching out into other departments of the water-works field. On the other hand laboratories established for quite different purposes are co-operating with the water-works. The one instance that occurs to me is the one done at Washington under the inspector of asphalt and cements, where a very large amount of asphalt has been put down, but where the chemist in charge of that work has in the past done quite a large amount of water analysis.

At Worcester there has, of course, been established for a long time a laboratory in connection with the purification works, but within the past two years the Sewer Department has established another laboratory in the City Hall where chemical work and other work is being done for the Sewer Department, and they in turn have been doing some work for the Water Department and for the Board of Health, so that one department is helping another, and suggestions are arising to-day that show what a great field there is open for work in the immediate future.

The laboratory here, of course, has exceptional opportunities, as has been brought out by the paper, owing to the fact that there is such a diversity of characteristics in the water supply of Brooklyn. And it occurred to me, as it did also to one of the preceding speakers, that it is a matter of regret that we have not had the results from the laboratory available. It also occurred to me that the same thing very largely was true in connection with the work done at Boston, where material, especially in the biological field, has been accumulated in connection with the Boston water supply, but comparatively little of it to my knowledge has ever been available.

I do not know whether much more has been done in connection with the Lynn laboratory, but it is to be hoped in the future that this material which has been accumulating in Boston, Brooklyn, and elsewhere, will become as fully available to the general public as the work in some of the newer laboratories at Cincinnati, Louisville, etc., has been made available.

Mr. Provost. Mr. Provost.—I would like to ask Mr. Whipple what is the accepted theory for the absence of Asterionella in the Ridgewood Basin No. 2?

Mr. WHIPPLE.—There is no accepted theory, Mr. Provost. Mr. Whipple.

Mr. PROVOST.—Are the conditions considered more favorable for such growth at Mount Prospect? Mr. Provost.

Mr. WHIPPLE.—The conditions at Mount Prospect are more favorable. The water is deeper and the stagnation phenomena are more pronounced there than in the larger basins at Ridgewood. There is usually a larger growth of Asterionella in Mount Prospect Reservoir than in Ridgewood Reservoir. Mr. Whipple.

Mr. PROVOST.—You cannot prophesy the appearance of these growths in advance? Mr. Provost.

Mr WHIPPLE.—Not very well. We know, however, at what seasons they are liable to occur, and when they are present. We can judge by the organisms' appearance under the microscope as to whether or not they are in thriving condition. Mr. Whipple.

Mr. N. P. LEWIS.—Do you find many of these vegetable organisms in the small water supplies of the private water companies? Mr. Lewis.

Mr. WHIPPLE.—The Long Island Water Company's plant at Long Island City is an instance where we find them. They grow in that reservoir, where the conditions are similar to those at Ridgewood. The reservoir is near the Ridgewood reservoir. Mr. Whipple.

Most of the private companies, however, have very little trouble from these microscopic organisms, because the water is not exposed in open reservoirs.

Mr. MESEROLE.—Did you get these samples from the reservoir or from the taps? Mr. Meserole.

Mr. WHIPPLE.—From the reservoir. Mr. Whipple.

Mr. MESEROLE.—Don't you think you would get very different samples from the taps? Mr. Meserole.

Mr. WHIPPLE.—Yes, most of the time. If I remember rightly, the distribution system is so arranged that if the consumption is greater than the demand, the water is pumped directly into the pipe, and does not pass through the reservoir. Mr. Whipple.

Mr. MEEM.—I would like to ask about those growths that grow inside of the rusty pipes. Do they grow on the rust, or does the rust grow around them? You showed a photograph of some animal organism that appeared to be growing on the pipe. Mr. Meem.

The AUTHOR.—In answer to that I would say that these organisms, known collectively as pipe-moss, are found both upon smooth surfaces and upon rough surfaces. I have seen them growing upon the inner surfaces of glass tubes. But they no doubt avail themselves of the projections on rough surfaces and are usually more abundant in pipes of that character. It seems likely that their growth may influence to some extent the surface of the pipe. Tubercles, moreover, may form in pipes where these organisms are not present. The Author.

Mr. PROVOST.—I would like to ask one more question, if I may. Mr. Provost

Do the organisms form in the water from driven wells after the water has stood awhile in the reservoir, or are they present in the driven well water when it is drawn?

The Author. The AUTHOR.—The water as it comes from the ground is entirely free from the forms you speak of. They grow in the water after it has been exposed to the light.

Mr. Meem. Mr. MEEM.—How is the counting done?

The Author. The AUTHOR.—By what is known as the Sedgwick-Rafter Method. A photograph of the apparatus was shown on the screen. A measured quantity of the water is filtered through a miniature sand filter and the organisms caught on the sand are collected in a small quantity of distilled or filtered water, placed in a cell, and counted under the microscope.

The President. The PRESIDENT.—Some mention has been made of the number of laboratories that are installed by municipalities for the examination of other substances besides water. It may be interesting to know to what extent that has been carried on.

The first, as has been suggested by Mr. Baker, was in Washington, and the director of that laboratory has the title of Inspector of Asphalts and Cements, and as Mr. Baker also said was primarily instituted for the purpose of examining asphalts. It has since been carried farther, and they examine almost everything there that has been, or is used in construction work, besides the water. Now, I think that Brooklyn was the next city to take that up, and establish a laboratory on an extensive scale, although Philadelphia also has a laboratory, a very elaborate one, too, that must have been installed about the same time.

St. Louis, also, has a laboratory equipped with a great deal of chemical, and also physical apparatus, where they test nearly everything that is used in the way of construction in their municipal work, and within a year or so Kansas City has also taken up the work. So that, within the last four or five years, it seems to have been considered necessary to use these laboratories for general work, and that it also pays from an economical standpoint. Of course it is hardly possible to figure out in dollars and cents, or in any other definite way, just how much these laboratories are worth, but the work that has been done by them in the different cities has been so successful, and has accomplished such good results that the other cities have recognized their worth, and the subject is receiving a great deal of attention in all of the larger cities, and, as has been stated, about this laboratory at Mount Prospect, and the laboratory at Boston, it is a great pity that the work is not made public in some way, so that the other cities, and the profession as a whole, will derive benefit from them. This certainly would go a long way to convince the people of the other cities of the necessity for such laboratories.

BROOKLYN ENGINEERS' CLUB.*

No. 27.

DROP-FORGING.

By William J. Grinden, Mem. B. E. C.

Presented May 10th, 1900.

Before entering into the details of the subject of this paper it seems well to refer to the earlier history of the forging art, and to trace in a brief way its development. We are indebted to the Bible for our first knowledge of it, as, in the Book of Genesis, Chapter IV, Verse 22, can be read that Tubal Cain was a hammerer and artificer in every work of brass and iron.

Again, in the Book of Isaiah, Chapter LIV, Verse 16, is found the following: "Behold, I have created the smith that bloweth the coals in the fire and that bringeth forth an instrument for his work." This verse may have inspired Professor C. Schusselle to paint in 1864 his celebrated picture of "King Solomon and the Iron Worker." A Jewish legend tells us, however, that "When the Temple at Jerusalem was completed, King Solomon gave a feast to the artificers employed in its construction. On unveiling the throne it was found that a smith had usurped the seat of honor on the right of the King's place, not yet awarded, whereupon the people clamored and the guard rushed to cut him down. 'Hold, let him speak,' commanded Solomon. 'Thou hast, Oh King, invited all the craftsmen but me; yet how could these builders have raised the temple without the tools I fashioned?' 'True,' decreed Solomon, 'the seat is his by right, and all honor to the ironworker.'"

* This Club is not responsible, as a body, for the facts and opinions advanced in this publication.

Grecian mythology tells us that the Fire God, Vulcan, lived on the Island of Lemnos, off the coast of Thessaly, and, using a volcano as a furnace, forged the thunderbolts of Jupiter and the arms of the Gods.

The Cyclops, celebrated one-eyed giants, also forged thunderbolts in Vulcan's workshop. They might possibly now be called his helpers.

During the many centuries intervening very little progress was made in developing this art, although the product of the smith was always in demand. As an armorer, he was of vast importance owing to the continual warfare on the continent of Europe, but this particular industry diminished rapidly after the discovery and use of gunpowder.

It has always been considered one of the most important of the mechanical arts, and has occupied a place of high esteem, being frequently spoken of as a noble calling. Probably nothing pleased the late Elihu Burritt more than to be called the "Learned Blacksmith," while the title of "The Yorkshire Blacksmith," when applied to the Rev. Robert Collyer, had to him a most agreeable sound. Cornell College has a horseshoe made by Mr. Collyer shortly after the great fire in Chicago, where he was stationed, for which the faculty paid $1,000.

Remnants of mediæval methods are still found. Henry M. Stanley, in his book "Through the Dark Continent," tells us how he found the natives working iron as shown in Fig. 1. The picture which is here represented might be called "The Village Blacksmith." He writes: "At Wane Kirumbu Uregga (pronounced Wah-neh Ki-rum-boo Ooreggah) we found a large native forge and smithy where there were about a dozen smiths at work. The iron ore was very pure. Here were made the broad-bladed spears of Southern Uregga and the equally broad knives of all sizes, from the small waist knife an inch and a half in length to the heavy Roman sword-like cleaver. The bellows of the smelting furnace are four in number, double handled and manned by four men, who, by a quick up and down motion, supply a powerful blast, the noise of which is heard nearly half a mile from the scene. The furnace consists of tamped clay raised into a mound about 4 ft. high. A hollow is then excavated in it about 2 ft. in diameter and 2 ft. deep. From the middle of the slope four apertures are excavated into the base of the furnace into which are fitted funnel-shaped earthenware pipes, to convey the blast to the fire. At the base

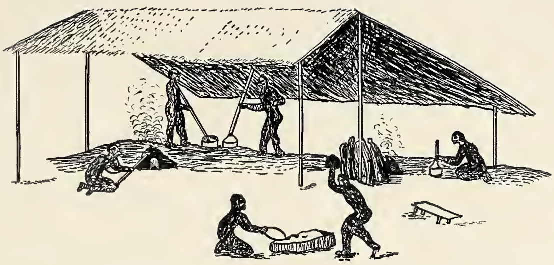


Fig. 1.—Native Iron Workers, Africa.

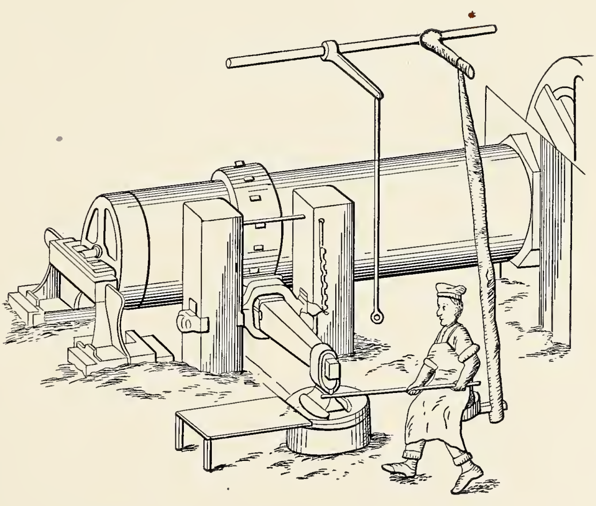


Fig. 2.—German Trip Hammer. Primitive.

of the mound a wide aperture is made for the hearth, penetrating below the furnace. The hearth receives the dross and slag. Close by stood piled up mat sacks of charcoal with a couple of boys ready to supply the fuel, and about two yards off was a smaller smithy where the iron was shaped into hammers, axes, hatchets, spears, knives, swords, iron balls with spikes, leglets, armlets and iron beads, etc. The art of a blacksmith is of a high standard in these forests, considering the loneliness of the inhabitants."

Forging of the present age can be divided into three distinct classes:

First.—Hand work.

Second.—Trip hammer or steam hammer work.

Third.—Drop hammer work.

The forge used in the hand method is built of brick, and blast is supplied by hand bellows. Modern requirements compelled many changes to be made in forge and blast construction, but the labor remains unchanged and is the same as used for centuries.

The second class, trip and steam hammer work, is a development from the hand method, and was a natural growth. It is to-day considered one of the most important arts connected with engineering work. It was somewhat difficult to obtain a sketch or cut of the earliest attempts in trip hammers, but Fig. 2, a sketch of a German trip hammer—antique—will somewhat illustrate it. This was made in Germany; perhaps the figure speaks for itself. The gentleman from whom the picture was obtained stated that all over that country these very hammers are now in use, the people not knowing there is anything better to be had. In one large cutlery manufactory in Solin he found ten of these driven by ten different engines, each one of which was large and powerful enough to drive five modern trip hammers. The operator did not know how to drive them all with one engine, as he could not figure out how any one could be started or stopped without starting or stopping them all. The driving cylinder of these hammers alone weighed 16 000 lbs., or more than twice the weight of the largest trip hammer now made.

Fig. 3, a modern Bradley hammer, illustrates the development of the old trip hammer just shown. It is belt driven and is one of the styles now in use. In the same class we can place steam hammers which are, in a measure, another sort of trip, only the driving power is direct steam pressure applied in a similar manner as to the cylinder

and piston of an engine. Fig. 7, a 1 500-lb. steam hammer (B. M. & Co.) will convey an idea of the general form and shape of a 1 500-lb. size. The largest one formerly in use was about 100 tons; hydraulic pressure has, however, superseded the larger machines of this type.

In the third class we find drop-forging. This branch of the art might properly be termed "blacksmithing by machinery" or the method of producing by mechanical means pieces made formerly on the anvil by hand.

About the year 1850 the English Government was making the celebrated Enfield rifle. It procured from different makers the requisite parts. One skilled in producing barrels would supply them, another the stocks; another would furnish lock parts, etc., and, at the Tower of London, these would be assembled into the complete rifle. It was necessary to fit by hand each piece separately, which fully taxed the skill of the gunsmith. It was not very long before John Bull saw the necessity of improving this branch of his work, and about the year 1854 or 1855 there was ordered from the Robbins & Lawrence Company in the little town of Windsor, Vt., the machinery to produce the gun on the interchangeable plan. The introduction of American tools caused a complete revolution in this industry, as it was soon found possible to machine each part so that exact duplicates could be obtained and this product thus greatly increased. As forgings were principally used in the various parts of the gun, it was found imperative to have them of uniform size so that they could be properly handled in special fixtures or holders while being machined. The drop-forging art was then unknown, and all pieces were made by hand, aided by dies in a manner shown by Fig. 4, taken from a sketch made by Mr. Chas. E. Billings.* This picture may not be very artistic, but it conveys the correct idea. The base was made of cast iron with a suitable opening at the top, into which the guide stock and lower die were fixed. The upper die was made to work freely up and down. In the faces of these two dies was cut the form required. The smith then hammered by hand the end of a bar of iron or steel into a rude suggestion of the shape wanted so as to properly distribute the stock, and placing this rude shape between the dies, forced it into the impressions by a series of blows from hand hammer and sledge.

* For information about the early history of drop forging, the author is indebted to Mr. Chas. E. Billings, Hartford, Conn.

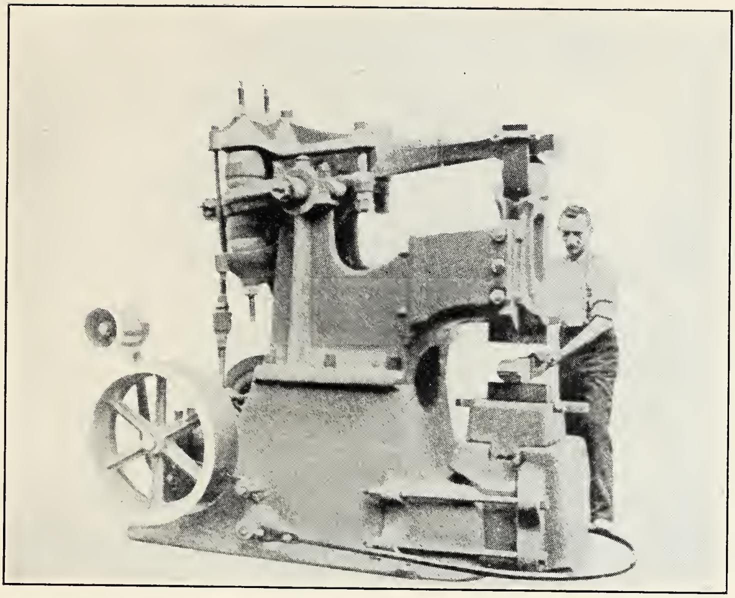


Fig. 3.—Modern Trip Hammer, Bradley.

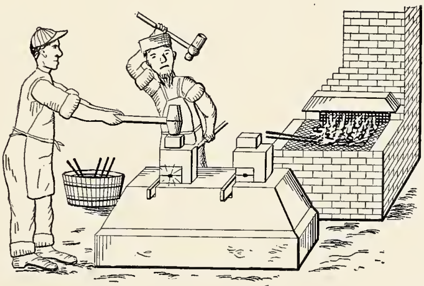


Fig. 4.—Die-Forging by Blacksmiths.

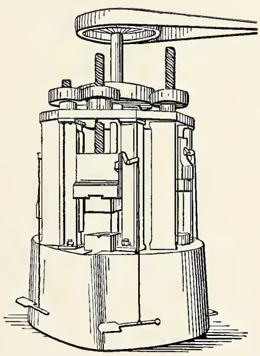


Fig. 5.—The First Drop-Forging Hammer.

The growing demand for fire arms developed the necessity of improvement in this line, and while during the years 1851 to 1853 there were one or two machines invented, it remained for Colonel Samuel Colt, maker of the celebrated revolver, to successfully use a drop hammer. It was designed by the late Elias K. Root, Superintendent of the Colt Works. Fig. 5 shows a sketch made from a description supplied by Chas. E. Billings, of the first drop hammer. It is only approximate, but it is impossible to obtain anything else, owing to the complete destruction of the Colt Works by fire some years ago. It has four hammers or rams which are guided by uprights or posts, and which are raised by a vertical revolving screw. The operator walked around the hammer, using the first pair of dies for "breaking down" or forming roughly the desired shape; the second, third and fourth pairs were then employed successively to finish the shape complete.

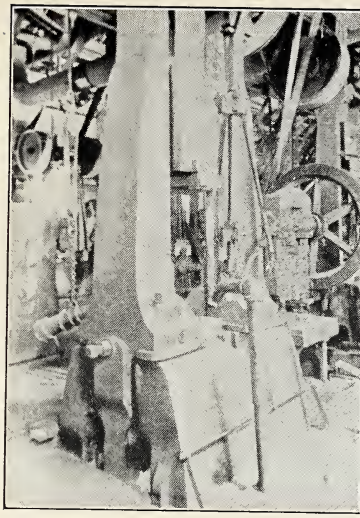
The next improvement was in 1862 to 1865, and was a development by Golding & Cheney, a Providence concern, who used friction rolls to raise the hammer, a leather belt being pressed between them. This hammer was quite successful. Improvements followed since that period until the present day, when the hammer shown in Fig. 6 came into existence. A brief description of it may be of interest. The ram, or hammer, as it is sometimes called, weighs 2 000 lbs. and is lifted by means of friction rolls on a maple board working on an eccentric. The operator trips the treadle, releasing the clamps holding the hammer, which immediately falls of its own weight. Into this hammer, fastened by means of a dovetail and key, is a die called the upper die. In the base of the drop is a similar dovetail opening, into which is fixed the lower die. When both die faces meet the complete article is formed. The base is a solid mass of cast iron, weighing usually fifteen times more than the ram, and is set securely on a timbered foundation. Where the ground is swampy, piling is necessary, topped with concrete from 1 to 2 ft. thick, and then Georgia pine timbers 12 ins. x 12 ins, securely bolted together, covering a space of 36 sq. ft., are finally placed on top, and it is ready to receive the base. The machine alongside is a press used for trimming the surplus material off the forging, an operation which will be explained in detail later.

The first step in this art, so peculiarly interesting to machinists and blacksmiths, and so little understood by the great mass of either

trade, is the making of the dies. A model of the part to be forged is usually made of wood, if it be a form not clearly shown by a drawing. When given this model, a scale drawing, the required weight of the finished forging, the die sinker has the principal data required by him for making the dies. To this information should be added, however, the number of forgings required and the allowable limit of variation from the stated dimensions.

After selecting the proper size blocks which have been planed smooth and made with the dovetails, the die sinker determines from his model the best parting line for the forging in much the same way as does the pattern-maker on a pattern for a casting, but the analogy between the two is comparatively slight as the conditions are radically different. The pattern maker can use cores and loose pieces to make cavities and overhanging parts, but the die sinker is practically limited to a die opening in two parts, which must be made to stand the roughest usage. The outline of the piece to be forged is drawn on the surface of the die which has been coppered with a blue vitriol solution, this causing the lines to stand out sharply. The metal is then removed in a manner that is most expedient for that particular example. If the outline be circular, the stock is turned out on a lathe. If the shape of the forging be such that other means are required for removing the metal from the die, the profiling machine readily furnishes a way for following the most complicated forms by means of milling cutters of various shapes and sizes. The shaper and milling machines are also impressed into service as well as the drill. Chipping by hand is commonly done, and in nearly every case a file, riffle, scraper and some emery cloth are required to finish the impression to the required smoothness and regularity. The forming of an irregular cavity in the face of a high carbon steel die so that when its mating die is matched to it the shape of the space enclosed will not vary from the specified dimensions more than $\frac{2}{1000}$ths of an inch either way is an operation requiring skill and patience. After the complete impression is made, a proof is taken by filling the cavity with melted lead. This is submitted to the customer, and, when his approval is received, the dies are finished completely.

A shallow space is cut in the face of each around the impression. This is technically called the flash of the die. As it is practically



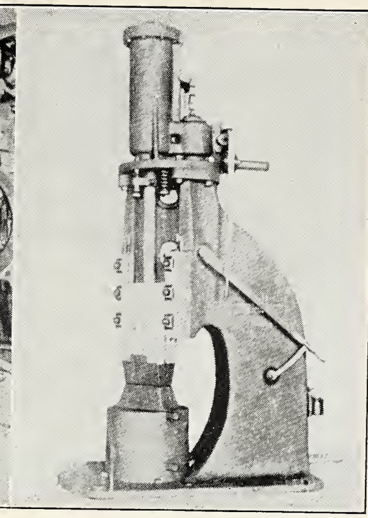


Fig. 6.—Friction Lift Drop-Hammer.

Fig. 7.—A 1 500-lb. Steam Hammer.

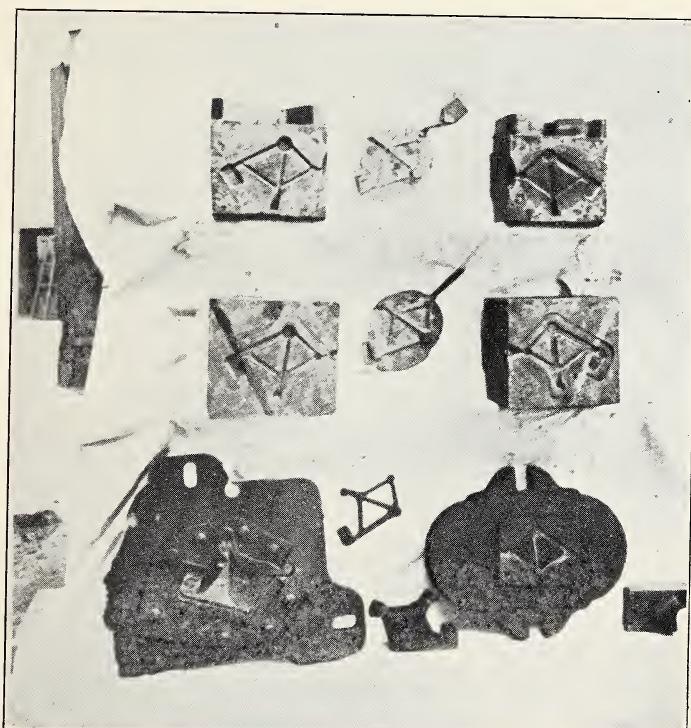


Fig. 8.—Dies and Forging, Three Stages.

impossible for the drop forger to form the bar or billet of steel into just the shape and size required for the forging, this space must be left for the overflow of surplus metal.

Trimming dies are necessary to remove the flash. They are made in male and female form; the upper part being the male die, and the lower one the female. The male die is made of the outline of the forging through the parting line, and with its face conforming to all the irregularities of the upper part of the forging. The female die is open at the bottom so that the trimmed forging can fall through it into a receptacle under the press. It is also made with its cutting edge conforming to the parting line. The dies are then heated carefully in furnaces, the heat of which is usually determined by pyrometer to insure the uniformity of temperature, and are then hardened. They are now ready for use.

In the forge department all sizes of hammers are required. They are as follows: 200, 300, 400, 600, 800, 1 000 1 200, 1 500, 2 000 and 3 000 lbs. The weight of the ram or hammer determines the size of it. When it is considered that the demand for drop-forgings ranges from pieces weighing one-sixteenth of an ounce to those of 100 lbs. weight, and covering all varieties of shapes and of the materials—iron, steel, copper, bronze and aluminum—one need not be surprised at the equipment. To illustrate one phase of the many sides of this art, a piece was selected somewhat complicated in shape. It is a shuttle carrier for a wax thread sewing machine. The dies, etc., used for its production are shown on Fig. 8. Those at the top are called the "breaking down" dies, those in the center are the finishing dies, and at the bottom are the trimming dies. In the center, between each die, is a specimen showing the progress of the article. The breaking-down dies are fixed in a 1 000 lbs. drop; the upper one in the ram, the lower die in the base. This applies also to the finishing dies. The trimming dies are set in a press. The operator selects the size stock by a careful trial, under the eye of a foreman. In this particular case the size is 2 ins. wide by $\frac{3}{4}$ in. thick.

In the upper part of the picture will be seen a piece of the original bar fixed to the rough plank. The bar is heated to about 1 500° Fahr. temperature in a furnace close at hand and by a series of blows alternating between the edge impression and the center one of the break-down dies, the metal is gradually worked from the size mentioned

into a shape fit to place in the finishing dies. It takes about thirty blows to accomplish this.

The next step is the finishing dies and after about ten blows are struck the forging is practically made to size, the surplus stock contained in the blank spreading out into a web-like shape mentioned before as the flash. The operator then places the forging while still hot on the trimming dies set in a press and shears off the flash and punches out the center and then gives the piece a final blow in the finishing dies to straighten and smooth it should it have become bent while being trimmed. A specimen of each operation may be seen here if desired. Sometimes this trimming operation is done when the article is cold, if the shape and size permit it, so as to economize in the cost of production. After this operation has been concluded each piece is pickled in a weak solution of sulphuric acid to remove the scale which forms while cooling, so that when machining the forging this scale will not dull the edges of the cutters, etc.

If a tool steel forging, or one containing a high percentage of carbon is required, an annealing operation is necessary before any machining can be done. I have here a few specimens of steel, showing the effects of the various heatings on the granular structure of it.

Fig. 9 shows some special work exhibited at the Paris Exposition of 1900. This gives an idea of the variety of work a modern establishment is called upon to produce. The necessary equipment of such a plant combines, in addition to drop, trip and steam hammers and presses, various kinds of machine tools, such as planers, shapers, lathes, profiling or die sinking machines, drills, milling and broaching machines, hydraulic presses, as well as many special machines.

Fig. 10 shows the interior of a modern forge.

The secret in drop-forging is to correctly make the dies so as to minimize the number of blows and the amount of material used, combined with a judicious handling of the dies themselves so as to prevent useless wear on them. This secret is not, after all, so wonderful if one reasons a little. First, determine which way the metal naturally spreads under the impact of the falling hammer and make your die accordingly. You can easily assist this natural law and obtain good results, but should you attempt to coax the stock in another direction, contrary to its own inclination, trouble will soon be yours.

Perhaps a brief reference to a concern located in this city, devoted

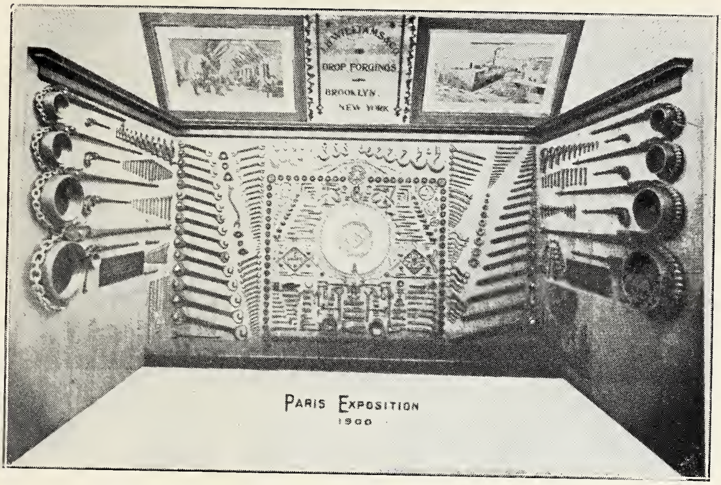


FIG. 9.—EXHIBIT OF SPECIAL DROP FORGINGS AT PARIS.

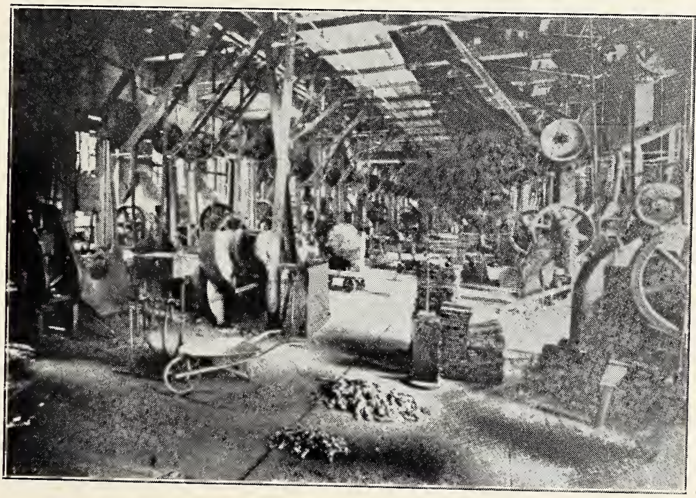


FIG. 10.—INTERIOR OF A MODERN DROP FORGING SHOP.

to this art, may not appear inappropriate. In the conduct of any industry two methods may be pursued, both diametrically opposed to each other in method, but each aiming at one result, viz., success. Either one can be called close management. One is to place at its head a sharp severe executive who reduces wages to the lowest possible rate and drives his employees by brute force. This may succeed temporarily, but there is much doubt as to its permanency. The other method is to select the best possible men, pay the highest rate of wages and establish conditions which will tend to benefit the employees, physically and otherwise. This latter method is the one pursued by the concern just mentioned and has proven successful. It may be interesting to itemize a few of these improvements. In the first place, sanitary conditions were considered of much importance. To be explicit, a quotation from a statement made by the head of the concern is given: "As it is acknowledged that habitual bathing prevents disease and promotes health and morality, baths for working people affect all classes of society. Employers are, therefore, under moral obligations to supply such facilities, and health, decency and humanity demand it, because few opportunities for personal cleanliness are afforded to any but the privileged classes." And as a result a toilet room was built containing a dozen shower baths, washing tanks, drying room for wet clothing, lockers, etc. Floors and windows are scrubbed and cleaned regularly, and minor details watched and cared for.

To promote good health in the polishing room, an exhaust system to remove all flying particles of emery, etc., was installed. This, however, is required by our State Law, but is not vigorously enforced. It may seem surprising to state that the men objected to it when it was first proposed, saying that it was not needed. Now they are of different mind. A spirit of humanity prompted the installation of a cooling system in the forging shops. The humid days of summer have no terrors now for drop-forgers as they are swept by breezes and are cooler at work than at play. It might also be mentioned that this proved to be a good investment if viewed from a monetary standpoint.

A little money judicially spent in the simple adornment of a grass plot and vines makes a pleasing appearance, and the works are often spoken of as the factory with the pretty vines on it.

To prevent distressing accidents great care was given to surround all machinery with safeguards of various forms. They have already been productive of good results.

The danger of fire, which is to be dreaded by any manufacturer, was ever uppermost in the minds of the management, and after much thought and expense a system was established which is considered highly beneficial. What might be called the equal of several steam fire engines was erected in the shape of a Worthington Fire Pump. This is under steam all the year round, and has several lines of hose ready for instant use. To aid this a sprinkling system was installed, and with the addition of a fire department of the employees, each with a certain duty to perform, comparative safety can be enjoyed.

A Mutual Aid Association was formed, each employee joining it contributing a certain weekly tax. Those contributing 10 cents receive, when sick, $6 weekly; those paying 20 cents, $11 weekly. A physician's service is given, and in case of death certain amounts are paid.

A spirit of good fellowship was established among all departments by a ball and picnic given by the Aid Association the first year, and which has continued regularly since then. The management has always been invited, and has frequently attended these affairs.

When placing insurance on the establishment a special policy was obtained for employes' own tools and at no expense to them.

The Saturday and Sunday Hospital Collection was brought to the notice of employees and, although the number of men is not great, the total amount contributed has exceeded, for the past five or six years, that of any other factory in this city.

In the early part of this year a prize system was established, and none but men under daily pay were allowed to participate. Certain amounts are to be awarded twice a year for the best ideas, and although this has been in force but four months, enough suggestions have been received to more than compensate the concern.

In Longfellow's beautiful poem "Evangeline," his reference to the forging art will serve as a fitting conclusion to this paper. In speaking of Basil the Blacksmith, father of Gabriel, he says, "He was a mighty man in the Village and honored of all men; for since the birth of time, throughout all ages and nations, has the craft of the smith been held in repute by the people."

DISCUSSION.

Mr. Calvin W. Rice.—I would like to ask the author if it is possible to produce a forging with a single die? Mr. Rice.

The Author.—It can be done, but it takes much longer to do it. To obtain a forging made with one die only, the exact amount of metal must be used which will completely fill the impression and no more. In this case there will be no flash, but practice has shown it much quicker to allow the surplus metal to flow in the cavity around the impression and then trim this flash away in another die. The Author.

Mr. Calvin W. Rice.—I would like to ask about the lack of uniformity in drop forgings, particularly copper. I have had a great deal of trouble with commutators. Mr. Rice

The Author.—That is because you did not buy your forgings from our concern. I am not very well posted on copper work, One reason, I believe, is that some concerns, in forging copper, use the drawn bar, which is hard, while others will take the soft, rough bar. If they put them through the same operation, the forging naturally refines it somewhat. The idea in buying soft bars is that it can be obtained a little cheaper than the hard one. Then, again, they may strike it more blows, which naturally hardens it. The Author.

Mr. Calvin W. Rice.—I should judge from the appearance of the sample that it was formed in one blow. Mr. Rice.

The Author.—It probably took ten blows to make it. The Author.

A Member.—How many forgings will a die make? A Member.

The Author.—From one die we may obtain 20 000 forgings and sometimes only one. It depends altogether on the luck you have with your dies. Sometimes a die will break. The Author.

A Member.—I would like to ask how you can get the alignment between the upper and lower head in making so large a number of forgings from one die? A Member.

The Author.—The only way to get that is to keep the dies set perfectly, and try a forging occasionally to see if it is perfectly matched. In the first place the two sides of the die are set evenly, and then, after a forging is made the piece is examined. Once you get them set, they generally remain that way for some time, but frequently you have to keep shifting the dies when they move out of place. The Author.

A Member.—Do you rely on the guides of the slide for very close alignment? A Member.

The Author.—That aids a great deal, but, of course, they wear. You have to depend on the two edges of your die to keep the alignment.

A Member.—How close do you fit the hammer on the slides? A Member.

The Author. The Author.—About a sixteenth of an inch.

A Member. A Member.—Are forgings hot or cold when finished?

The Author. The Author.—It is frequently seen that a forging after it is finished will appear hotter that when it is put into the die. The small pieces of steel shown here (indicating) are tool steel, and represent various grades. The first one is the steel itself; the second one shows it annealed; the third one shows the grain after hardening, and the last piece shows burnt material.

A Member. A Member.—I would like to ask, in the making of those bars, if annealing would not bring them to an uniform degree of hardness?

The Author. The Author.—Yes, if the steel has not been injured in forging.

A Member. A Member.—Do you have any trouble in working pure aluminum?

The Author. The Author.—Yes, there is trouble; it occurs in heating. It does not stand very much fire. That piece you have in your hand (indicating) is made out of three-eighths round.

Mr. Rice. Mr. Calvin W. Rice.—I would like to ask how the art here compares with that in Germany?

The Author. The Author.—America is much in advance of any other country in this art, particularly in accuracy and closeness to given dimensions. Manufacturers here obtain orders chiefly on this account, as prices abroad are generally lower than in this country.

A Member. A Member.—I would like to ask what difference there is in the size of the die and the finished article? How much shrinkage?

The Author. The Author.—When the impressions are machined, one allowance is made only; that is the natural shrinkage of the forging. When a die is produced by casting to a form, a double allowance must be made. First the shrinkage of the die when cooling, and then the shrinkage of the forging when it is made in the cast die.

A Member. A Member.—How far do the hammers fall?

The Author. The Author.—We have hammers which allow a drop of 4 or 5 ft.; the limit ranges from that down to 6 ins. There are hammers made where by means of the pedal you can bring the hammer up and down with a varying blow just as you want, the same as a steam hammer. A drop hammer falls in a manner similar to a pile-driver on the face of the lower die. When your foot is removed from the pedal, the hammer immediately rises. It strikes about sixty or seventy blows a minute.

Mr. Torrance. Mr. Kenneth Torrance.—Is one blow sufficient for drop-forgings?

The Author. The Author.—No, unless it is a very simple one. If it is a complicated forging, you have to coax the metal in various ways by a number of blows.

BROOKLYN ENGINEERS' CLUB.*

No. 28.

THE ELECTRIC CONDUIT RAILWAY—ITS DEVELOPMENT AND CONSTRUCTION.

By F. G. Cudworth, Mem. B. E. C.

Presented October 11th, 1900.

The history of the development of the electric conduit railway is but a repetition of the successes and failures that have marked the development of every branch of electrical science, and its present high state of efficiency stands as a monument to the untiring energy and perseverance of the electrical workers of the last quarter of the nineteenth century.

Commercially speaking, electrical traction dates back scarcely fifteen years. It was introduced into the United States as an experimental railway at the Chicago Exposition in 1883, four years after it appeared at Berlin.

In the fall of 1884, there was opened to the public at Cleveland, Ohio, 1½ miles of underground slotted conduit road. This was probably the first attempt to operate, on a commercial scale, any form of street railway, by electric traction, in the United States. It was certainly the first attempt at slotted conduit construction in this country, and while this attempt may not be safely styled a complete success, it was by no means a failure, being operated for nearly two years. The service was not sufficiently satisfactory to warrant its continuance.

In the Cleveland construction the Bentley-Knight Company used a wooden conduit, placed midway between the rails, the conductor bars

* This Club is not responsible, as a body, for the facts and opinions advanced in this publication.

being supported in very much the same way as in our more recent construction. Their motor was hung from the car body midway between the two car axles, and was connected to the axles by wire cables. This was, perhaps, the weakest point of the Bentley-Knight construction. While they realized one of the essential features of the motor problem, they did not at that time grasp the importance of the other, viz., that of positive gearing.

Late in 1884 there was witnessed the erection of the first practical overhead copper trolley wire in the United States, by J. C. Henry at Kansas City; 1885, 1886 and 1887 saw rapid advancement made in both line and motor construction. Early in the latter year Sprague commenced the construction of overhead trolley lines at Richmond, Va.; St. Joseph, Mo., and Wilmington, Del. But it was not until 1888 that the commercial street railway was in practical operation in the United States. In this year several roads began to operate and to carry passengers on schedule time.

Among the most successful lines were the Sprague road, at Richmond, Va.; the Thomson-Houston system, at Washington, D. C., and a conduit road installed by Bentley & Knight, at Allegheny City.

That the early workers upon the problem of electric traction realized that the only feasible method of operating cars electrically was by some means of underground propulsion is proved by the repeated attempt, both in this country and abroad, to construct a successful conduit system.

It was recognized from the outset that this system must be much more costly; nevertheless, the urgency was felt to warrant the outlay, and numerous and expensive attempts were made to construct a conduit suitable for the successful and economical operation of cars. There is little doubt that this problem would have been successfully solved at this time, had not Sprague early in 1888 demonstrated the entire practicability of the overhead trolley, and thus offered a much cheaper substitute.

During 1888 and 1889 Bentley & Knight were making for the West End Street Railway Company, of Boston, the most pretentious efforts to solve the underground problem ever undertaken. The West End Company at that time was the largest street railway in the world, not only in miles of track, but in number of cars operated.

The signal failure of this experiment, after almost six months of

attempted operation, during which time the system met with daily, almost hourly, breakdowns and delays, convinced the officials of the West End Company, and the public in general, that the underground conduit road could not be successfully operated, and led to the equipment of the entire West End system with the overhead trolley. This failure of the West End Company to construct a successful conduit road practically stopped all further experiments along the line of underground construction, and gave a great impetus to the overhead trolley. The pronounced success of this latter system, as a means of urban transit, led to its rapid introduction into nearly every city in the United States, and the history of the development of the overhead trolley to its present high state of efficiency within the short space of ten years is without a parallel in the annals of the world's engineering.

It is safe to say that, had it not been for the stubborn and persistent refusal of the municipal authorities of New York City to consider any form of electric traction which contemplated the use of overhead wires, we should have had few experiments in the line of underground construction after the disastrous failure on the West End Road. As it was, the officials of the Metropolitan Street Railway Company were compelled to seek for some system of traction equal, if not superior, to the overhead trolley. They turned their attention to the cable as the most desirable substitute. Plans were prepared, and in 1889 construction commenced. Yet on January 1st, 1893, the entire railway system of New York City. with the exception of a cable line on One Hundred and Twenty-fifth Street and Amsterdam Avenue, was operated by horse-power, although the spring of this year saw the Broadway Cable Line from Fifty-ninth Street to the Battery (10.2 miles) put in operation. Construction was continued, and in 1895 15 miles of additional cable lines on Columbus, Ninth and Lexington Avenues were opened. During this period of cable construction the company's engineers had not been idle. It was more and more evident that in spite of the improvements in the cable it would not do for a system as large as that now operating on Manhattan Island. Its gigantic power plants and street vaults, many of these containing sheave wheels a score of feet in diameter, could only be built and operated at a tremendous expense. It was recognized that the enormous cost of cable construction would alone limit its extension, and the directors of the Metropolitan Street Railway Company cast about for some other form of mechanical

traction which would equal, and, if possible, be an improvement on, the overhead trolley.

The growth of electric traction abroad had not been characterized by that whirl which had marked its development in America. Consequently the extension of the overhead trolley had been slow, and, owing to extended prejudice against overhead wire in general, engineers had spent considerable time in perfecting the underground system. At about the time of the Bentley-Knight failure on the West End system in Boston, a conduit road was constructed in Buda-Pest, Hungary, by the Siemens-Halske Company, and, as it was constructed in a very substantial manner, it is not strange that it proved a success from the start. The Buda-Pest road is built with the slot adjacent to the tram rail and not in the center of the track, as with the cable and conduit roads constructed in this country. In this case the slot serves, not only for the plow, but also as a groove for the wheel flange, consequently it is made much wider, and is, in the Buda-Pest system, $1\frac{1}{8}$ ins. wide.

In this country many light road wagons have tires only $\frac{3}{4}$ in. wide. Consequently, the slot is limited to a maximum width of $\frac{3}{4}$ in., and cannot be used as a wheel groove, as the flange requires a greater width. Again, in the design of "special" work, where there is a complication of frogs, switches, turnouts, the center slot renders the design less complicated, and is to be preferred.

In 1892 William C. Whitney, one of the controlling spirits of the Metropolitan Street Railway Company, offered a reward of $50 000 for a system of mechanical traction suitable for the 190 miles of road then controlled by this company in New York City. It was proposed, in order to have the sanction of the State, and that the disposal of this princely reward might be entirely free from prejudice, to place in the hands of the State Board of Railroad Commissioners both the investigation of the plans submitted and the final award. The Board decided, however, that it had no power to determine the matter, consequently the applicants began to forward their schemes to the railway officials, who were, in an exceedingly short time, completely swamped by the multitude received, nearly all of which were of an impracticable nature. It was clearly seen that if any advance was to be made, the company must go into investigations on its own account. It was felt that the company could afford to spend a large sum in conducting experiments

necessary to develop a system. The problem that confronted it was not only the development of an entirely new system, but with the reconstruction of some 200 miles of lines, so interwoven and united that one system must be adopted for the larger proportion.

That this was no easy problem was realized from the start. To install a system that would ultimately prove a failure and have to be abandoned would mean the loss of the entire sum expended; consequently it was decided to send the company's engineer abroad, not only to investigate the Buda-Pest conduit system, but all kinds of mechanical traction then in use on the Continent. After a detailed examination of the workings of the Buda-Pest conduit road, and a careful study of the drainage conditions, as compared with those of New York City, the engineer reported that he considered the underground electric conduit system which had been in operation in Buda-Pest for several years entirely superior to all others examined by him, and recommended its adoption, with modifications, by the company. He had examined, among other systems, hot water, compressed air, gas motor and storage battery. The Metropolitan Company proposed at this time to construct some 5 miles of cable road in the northern part of the city, on Lenox Avenue. In accordance with the report of its engineer, however, the company decided to equip this line experimentally, with the electric conduit system, conforming the construction as nearly as possible to its standard cable work, so that in case of the failure of the experiment the road could be changed to cable at a minimum expense. A contract was entered into with the General Electric Company of New York, by which the electrical equipment was to be installed, and the road turned over to the railway company to operate for one year. If at the end of that time the road proved unsatisfactory, the electric company was to remove the equipment without cost to the railway.

Construction was commenced in September, 1894; the first car was operated April 1st, 1895, and the Railroad Commissioners officially inspected the road during the same month.

This is, in brief, the history of the first attempt at operating an underground conduit street railway in New York City, and the success that marked the early operation of the Lenox Avenue road was most pronounced and the difficulties attending its operation much less than those usually encountered in operating an overhead trolley road.

In the first two years of operation of the Lenox Avenue road there

developed a few mechanical faults which had to be corrected, but there has been no serious interruption of the service, although the road has been in continuous operation twenty-four hours a day. Snow has given much less trouble than was expected, and after nearly six years of operation, it has been demonstrated that the underground electric conduit system is superior to the overhead trolley in the point of successful operation, and in economy of maintenance, and it is the writer's opinion that the conduit system can be operated under all climatic conditions with no more difficulties than will be met with in running any form of mechanically operated road.

From this successful experiment the growth of the conduit system in New York City has been extremely rapid. It has been improved step by step. As weaknesses have developed under the strain of operation they have been removed and improved in the later construction, until the present standard, now in use by the Metropolitan Street Railway Company, for all slotted conduit work, is as near perfection as it is possible to carry a piece of mechanism.

The design has been criticized as being too heavy, and in the case of the Third Avenue system, which has lately completed its electrical equipment, it has been modified in a marked degree. Radical changes have been introduced in the method of track construction, which time alone shall justify or condemn.

The tendency of the Metropolitan construction has been toward a firm, unyielding roadbed, while that adopted by the Third Avenue road has been the opposite. The latter company in its new construction returned to the old form of a longitudinal stringer beneath the "tram" rail, and, in the reconstruction of its old cable lines, the company placed a stiff spring beneath the rail-base to give elasticity to the road. This would appear to be a step backward, if we are to draw conclusions from the earlier experiments along the line of underground conduit developments, as the failure of these earlier experiments are all traceable to mechanical weaknesses.

It is a comparatively easy matter to construct a track for a steam or overhead trolley road, but when it becomes necessary to construct a longitudinal slot, the edge of which overhangs the supports, and to maintain this slot at a uniform width under all conditions of temperature and traffic, the problem becomes somewhat complicated.

Many of the common kinds of paving material, granite, wood, etc.,

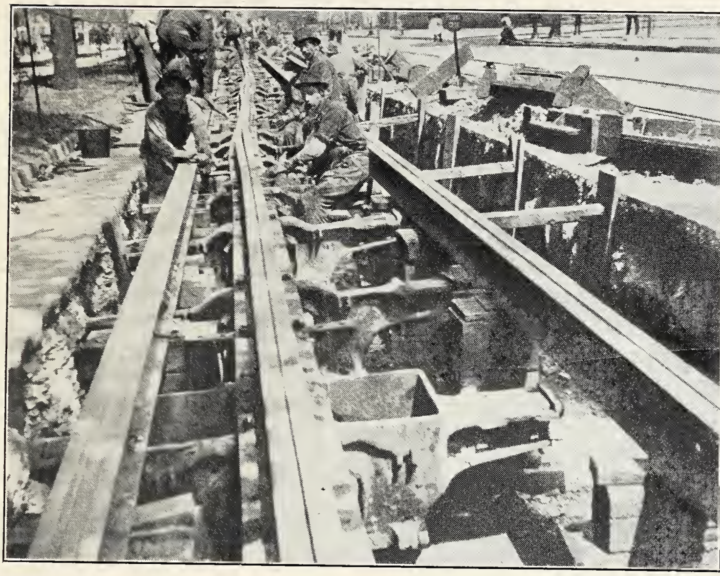


Fig. 1.—Single Slot Construction, Showing Box Yoke.

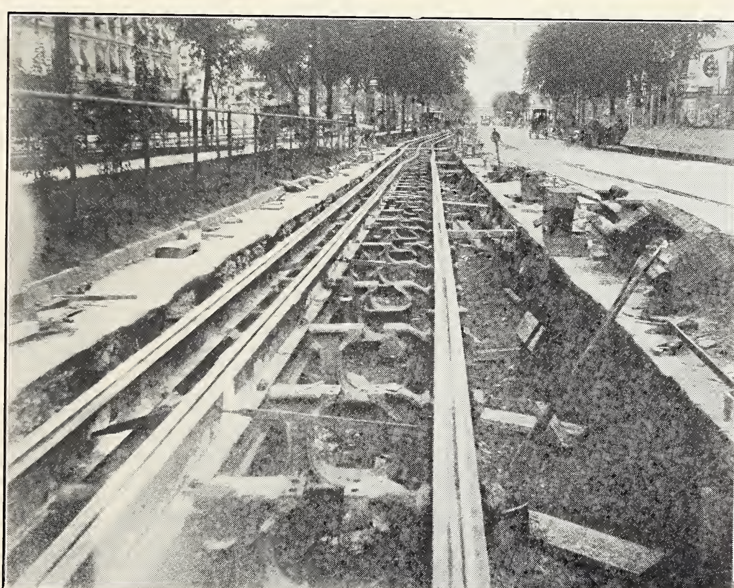


Fig. 2.—Duplex Yokes in Position, Showing Insulators and Power Rail.

expand to a considerable extent under different climatic conditions, and with a slot in the street the tendency is to expand in the direction of the slot. Consequently it is necessary to construct the slot sufficiently strong to withstand this expansion. This has been provided for in the more recent construction by using a comparatively heavy yoke. It will be seen that this expansion is a very serious matter, as the shank of the plow is $\frac{5}{8}$ in. thick, and the slot itself is only $\frac{3}{4}$ in., leaving a clearance of $\frac{3}{16}$ in. between plow and slot rail. Besides this, the slot rail is subjected to a heavy strain from loaded trucks passing over it, consequently the rail and yoke must be proportioned to meet these excessive strains without being deflected or closed up, and the foundations necessary to support these yokes must be of a most substantial character.

The construction of special work where one or more lines cross is in itself a complicated piece of mechanism, but when that design must be made to withstand the strain of a loaded truck carrying from 40 tons to 60 tons, it presents a very difficult problem in mechanical engineering.

Taking up the main features of track construction, we will describe a section of standard track work, giving the method of construction as adopted in New York City. The yokes are placed 5 ft. part, center to center, every third yoke being a so-called "box yoke." This is a cast-iron yoke, considerably heavier than the ordinary yoke, and arranged to receive the insulators for supporting the conductor bars. The foundations are, in all cases, of concrete, usually 6 ins. deep under the base of the yoke, and tamped in around it in the same manner that ballast is used in steam railroad work. Figs. 1, 2, 3, although taken from double slotted construction, or duplex work, give a good idea of the general features of track construction. Fig. 1 shows the yoke bolted to the slot rail, every third one being a "box yoke." It also gives an idea of the excavation necessary, in which to assemble the different parts of the track iron and to allow of feeder ducts being laid at one side. Fig. 2 shows the duplex construction in place, excepting the second slot rail. In this construction which occurs in a number of places in New York, where two companies were compelled to use the same right of way, an additional conduit and slot are built in a single track, and as in the case of the illustrations shown, this second conduit was built, while the road was being operated by the under-

ground trolley, cars passing every three minutes. It will be noticed that the duplex yokes are all of the same section, that is, there are no box yokes. In their place is used a detached hand hole box. These boxes extend down to the bottom of the conduit and are shown in position in Fig. 3; this latter figure also shows both slots in position and the track assembled and lined, ready for concrete.

In this duplex construction each company furnishes its own power, necessitating two separate lines of feeders and feeder ducts, manholes, etc.

Referring again to Fig. 2, the power rail and insulator will be noticed attached to the slot rail. These are the same that were in use on the single conduit, the slot rails, power rails and insulator being moved bodily to one side to make room for the additional conduit. Fig. 1 also shows workmen in the act of moving this slot and power rail to one side, and the method used to support slot and tram rails while new duplex yokes were substituted, power all the while being on and cars running. Fig. 4 shows the duplex yoke. Actual construction is carried forward in the following manner:

From a "base line," previously established on the sidewalk, the center of the track is staked out, and the excavation carried down to sub-grade. Forms are now placed in the excavation so that concrete can be laid for the foundation of the yokes. The concrete is deposited along the line of each track, usually some 6 ins. wider than the base of the yoke, and where the feeder ducts are laid at the same elevation as the bottom of the yokes, it is made wide enough to receive them. The iron is now placed in the trench, the rails bolted to the yokes, and the track brought to the proper line and grade by means of wooden blocks and wedges. Concrete is now rammed around the base of the yokes and brought up between the yokes as far as the bottom of the conduit. The conduit is now ready for the sheet-iron lining. While the conduit itself is of concrete, it is made by placing sheet iron forms between the yokes and ramming concrete against them; these forms are afterward removed, leaving a continuous tube of concrete. Earth back-filling is now brought up to within 15 ins. of the street surface, and the entire space between tracks, and for a distance of 2 ft. on the outside of the rails, is covered with a 6-in. layer of concrete. This forms the foundation for block paving, and in the case of asphalt, this concrete is brought up to within 3 ins. of the surface. Feeder ducts are usually

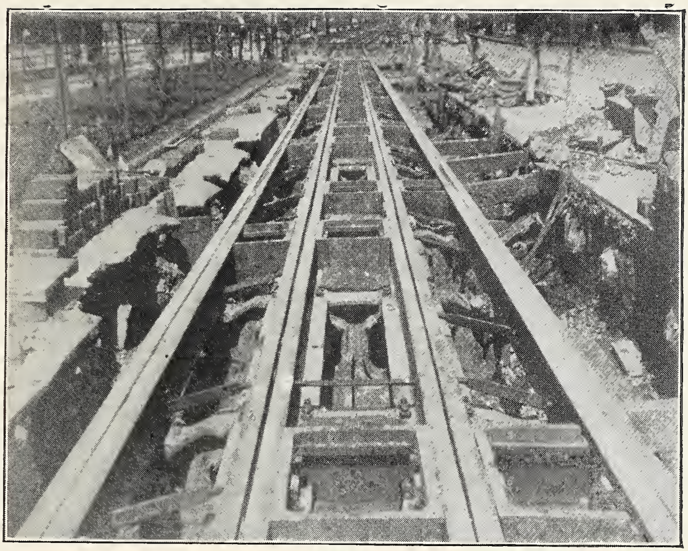


Fig. 3.—Double Slot Construction, Showing Double Slots in Position.

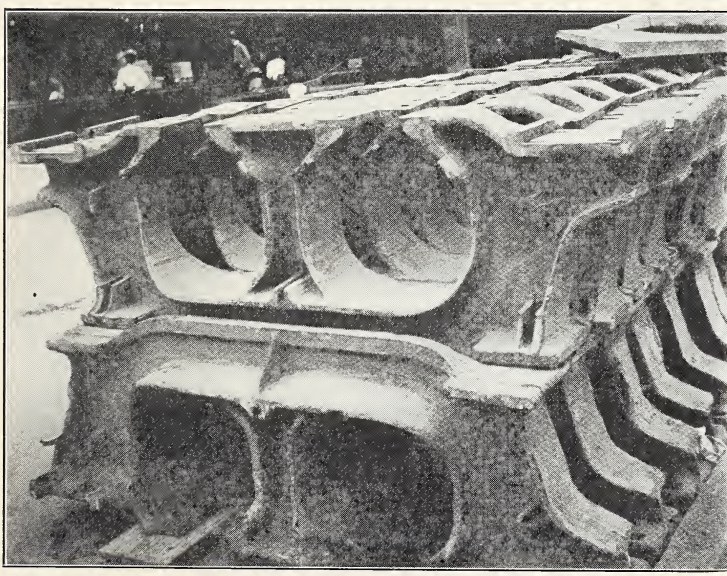


Fig. 4.—Duplex Yokes.

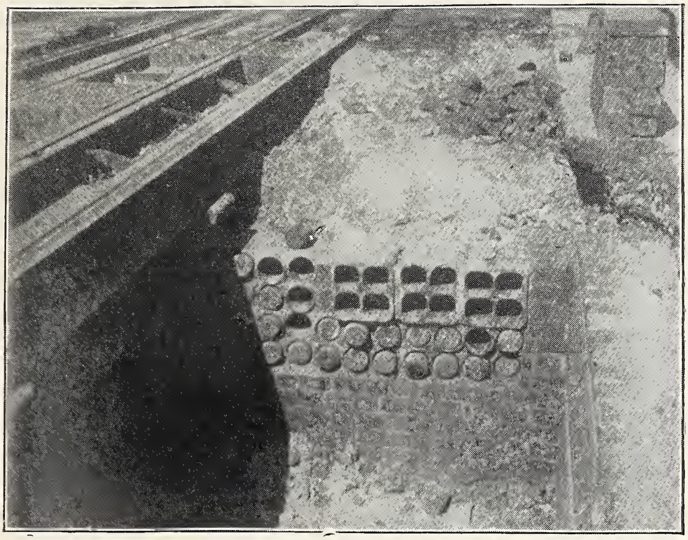


Fig. 5.—Feeder Conduits in Manhole.

Fig. 6.—Reverse Curve, 42d Street.

laid along the outside of the rails in connection with the track work. There are no special numbers of these tubes, enough being put down to supply the present traffic, and to provide, as far as possible, for future growth. Manholes are built about every 400 ft. to allow connection being made with the feeder cables and conductor bars. Fig. 5. These manholes are generally about 5 ft. wide and 4 ft. deep, and are long enough to permit of repairs being made to the cables, and for a new one to be drawn in without removing the street pavement otherwise than to take off the cast-iron cover at the street surface.

The conduit itself is connected with cleaning manholes at intervals of from 95 ft. to 125 ft. These are for the purpose of draining the conduit, and to allow the removal of all accumulations of dirt, etc. They differ from the feeder manholes in that they extend from outside to outside of tram rails only, the entrance being between tracks. Each is connected to the nearest sewer with a 6-in. drain pipe; in fact, the best method is to connect all manholes, both feeder and cleaning, with the sewer, and provide each with a fair-sized sump hole, from which a trapped drain leads to the sewer.

It was the practice, in the early conduit construction, to place these cleaning manholes 200 ft. or more apart, but it was found that the rapid accumulation of mud, which made it necessary to clean the conduit at least once a month in summer and oftener during the winter months, was so large that difficulty was experienced pushing the same to the manholes. This was especially the case with snow, which, finding its way into the conduit, became softened from the difference in temperature; and in a number of cases packed hard enough to break the plow before it was pushed to the manhole.

Different methods are used in cleaning the conduit, both horse and hand scrapers being used to drag the mud to the manholes, where it is removed and carried away. Recently an electric cleaning car has been developed, which is proving very successful.

In the electrical operation of the road the current is taken from the cable to a ⊣-shaped conductor bar. These bars are in 30-ft. lengths, supported at each box yoke every 15 ft. by a heavy bottle-shaped insulator. The bars are placed in the conduit 6 ins. apart, face to face.

The contact is made by means of a plow. This consists of a steel shank attached to the truck of the car, and extending down into the conduit. It carries at the lower end two steel springs, to which are

fixed cast-iron shoes, shaped a good deal like a large spoon bowl. These shoes slide along the conductor bars and take the current from the bar to the shoe; from the shoes insulated copper wires lead to the motor. The path of the current is from the positive bar to the cast-iron shoe; thence along the insulated wire to the motor, through the motor to the wire on the opposite side of the plow to the negative shoe and negative conductor bar.

To facilitate the operation, the bars are divided into sections, usually 1 mile in length. These sections receive the current direct from the power station independent of all other sections on the road, and as both incoming and outgoing feeders are provided with independent switches at the power station, it is possible, in case of trouble on the line, to cut off any particular section without interfering with the cars on any other portion of the road. Another important fact in connection with this sectional arrangement of feeders, in the operation of a conduit road, which does not appear in overhead trolley operation, is that as both sides of the circuit are insulated from the ground, in the conduit system, leakage, when it does occur, must arise on one side or the other of the circuit, consequently this sectional arrangement of both conductor bars and feeders makes it possible to correct all trouble from grounds, and renders the interruption of traffic through the grounding of conductor bars impossible. With the positive and negative feeders connected with double-throw switches, it is a very easy matter to reverse the polarity of the conductor bars in any one section by simply throwing the feeder switches from one terminal to the other. For example: If a ground occurs on a positive bar in any one section no trouble will arise unless another ground occurs on the negative side; in fact, several grounds might occur on the positive side without causing any trouble in operation. But let a positive and negative ground occur at the same time, even if a mile apart, there will doubtless be a serious loss of current, and probably an interruption in the service of the line. In such a case the engineer at the power station reverses the polarity of the bars on one of the grounded sections by throwing over the switches. The positive side is made negative, and the flow of current is immediately stopped, as both grounds are flung on to the same side of the circuit. In this way the only trouble that can seriously affect the operation of the underground system is guarded against.

Fig. 7.—Cleaning Rail Joint with Sand Blast before Cast-Welding.

Fig. 8.—Pouring a Cast-Weld Joint.

The voltage adopted on the conduit lines is now the same as the standard for the overhead trolley—from 500 volts to 550 volts. The weight of rail used has been steadily increasing until at present it has exceeded that used by steam roads. Weights in 1898 were as follows:

Kinds of rail.	Length.	Weight.	Wt. ft. of track.	Wt. per yd.
Tram	30 ft.	1 070 lbs.	71⅓ lbs.	107 lbs.
Slot	30 "	570 "	38 "	57 "
Conductor bar	30 "	210 "	14 "	21 "
Regular yoke		415 "		
Box yoke		611 "		

Trams, 9-in. girder; slot, 7-in. Z-bar.

The standard for 1900 is a 60-ft. girder, weighing 109 lbs. per yard, while that adopted for the reconstruction of the Broadway cable is a 7-in. girder, weighing 107 lbs. per yard. This latter is connected by probably the heaviest and strongest fish-plate ever used in a surface road.

The Third Avenue road in its reconstruction work adopted a 60-ft. tram rail of the girder section (Fig. 6). On the Third Avenue line, where the old cable conduit was utilized for the electric equipment, the old yoke limited the rail used to a 7-in. girder, having a 4-in. base. Accordingly a rail of that dimension of the standard New York section, weighing 104 lbs. per yard, and in 60-ft. lengths, has been used with the Falk cast-welded joint. The percentage of carbon in the new rail is 0.6 per cent.

The Metropolitan Company, during the present season, adopted the cast-weld joint for the first time, using it on the old rails of the Lexington Avenue cable line (Figs. 7 and 8). This rail was a 7-in. girder badly out of line, and in some cases very much worn. The joint has stiffened the rail a considerable extent, and has made a marked difference in the ease of riding, but as to its prolonging the life of the old rail sufficiently to warrant the expense of the joint, is, in the writer's opinion, doubtful.

The cost of the cast joint is $4.25. This includes cleaning the rail with the sand blast, and furnishing all material necessary to properly weld the same. The cost of excavating and relaying pavement around joint was about $2.70, making the total cost of joint in the neighbor-

hood of $7. This, at the present market price of steel rails ($26), is a little more than half the cost of replacing with a new rail.

Feeder ducts in use in New York City consist of three different designs. The McRoy earthen tile in clusters of four, each 3¼ ins., inside diameter, 6 ft. long. These were laid with three styles of joints. The first method was to use three pieces of burlap, two pieces being wrapped around the joint dry, the third being dipped in hot tar and placed around the other two. The second method used the same amount of burlap, cement being used in place of the tar on the last wrap. In the third method a dry wrap was used. In this the burlap is put on dry, being held in place by wires or narrow strips of sheet iron.

The National duct is of sheet iron, cement lined, 3¼ ins. diameter, in 6-ft. lengths. It has male and female joints, and is laid in cement mortar.

The Camp duct is an earthen tile, 18 ins. long, 3¼ ins, diameter, and s laid in cement mortar without special wrap.

As regards the cost of underground conduit construction, it is almost impossible to give an intelligent answer, owing entirely to the local conditions. This is especially true in New York City, where account must be taken not only of numerous subsurface obstructions, such as pipes, drains, sewers, etc., that must be taken up and relaid. but entire streets in a large number of cases have to be repaved. All this, combined with the extremely high price of special work, tends to bring the average cost per mile of single track to about $90 000, including feeders. Outside of New York City, where there are less stringent rules relating to the relaying of old pavement, and where there are less subsurface obstructions, the underground electric conduit system can be installed for $35 000 to $50 000 per mile of single track.

The actual cost per mile of single track in the New York construction has been as high as $150 000, while special work at intersections has cost much higher; that at Twenty-third Street and Sixth Avenue costing $59 650; Canal Street and West Broadway, $48 869; one double cross-over and two double-track turnouts at Thirty-fourth Street and East River, $95 333.97,

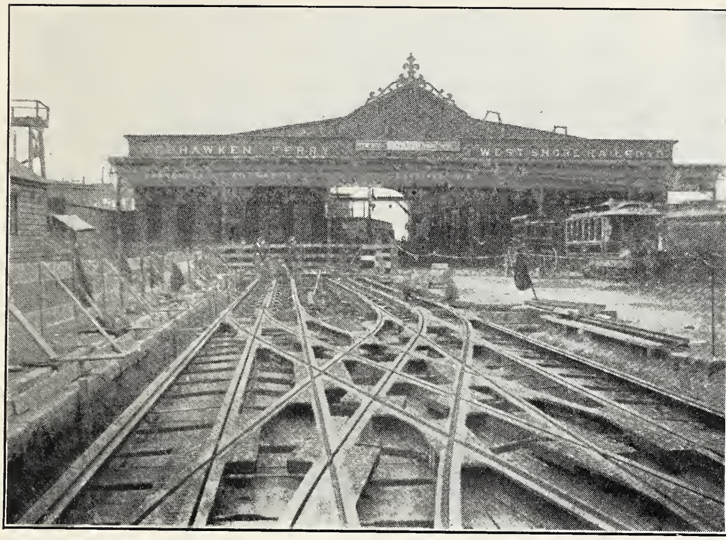


Fig. 9.—Special Work. Double Cross-over.

Fig. 10.—Special Work. Straight-away Crossing.

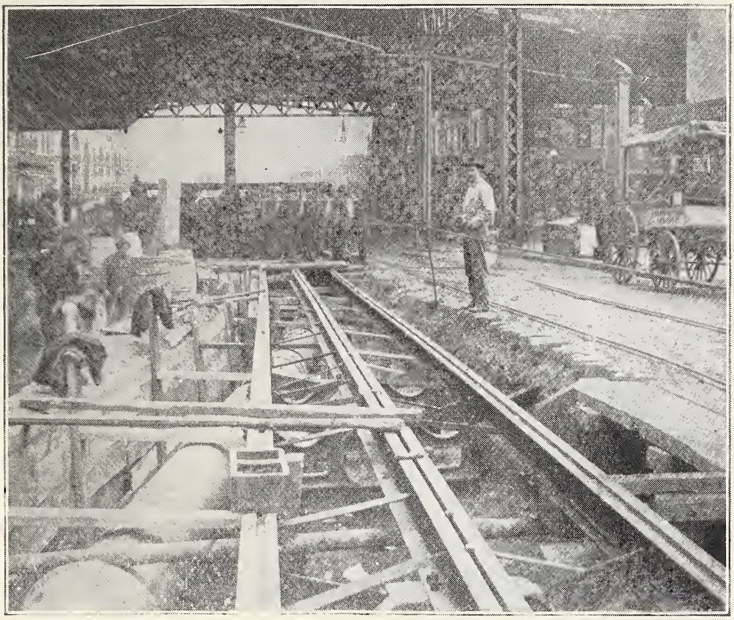


Fig. 11.—Obstructions. A 30-Inch Gas Main.

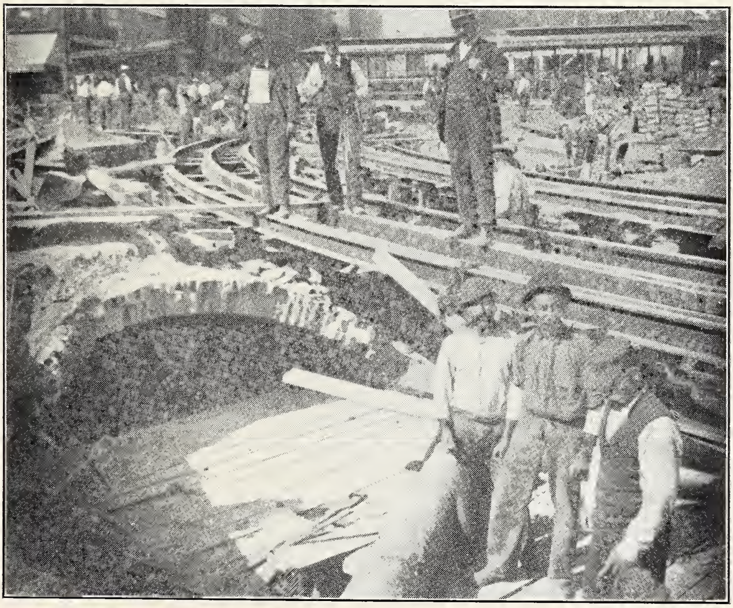


Fig. 12.—Obstructions. Trunk Sewer, Canal Street.

DISCUSSION.

Mr. Rice.—I want to express my interest and thanks for this valuable paper on railway construction work now in progress in New York. The first mentioned system was in Boston, and was installed in front of the college which Mr. Chase and I were attending, so that I then had opportunity for watching its construction. Mr. Rice.

The cost of construction must seem, to most of us, $90 000 to $100 000 per mile, to be so great as to be prohibitive. I would like to inquire what would be the expense, in round numbers, under most favorable conditions, for new construction in a city, not like New York, with so many underground complications, but where there would be straight-away construction without extraordinary difficulties.

The Author.—I should say that the cost of underground construction under the most favorable circumstances would be from $30 000 to $50 000, which price would include everything. The Author.

Mr. Tillson.—Would that include power-house? Mr. Tillson.

The Author.—No, but it would include feeder ducts and cables. The Author.

Mr. Rice.—I would like to ask about a feature we have all observed, that is, the different experiments in pavement between the rails. You have noticed on the line of the Third Avenue construction that they used, first, about an inch of asphalt pavement, which rapidly gave out. Then they used a cast-iron grate which was filled with asphalt, and I have seen a good deal of that removed, and I have seen them putting back asphalt of about 2 ins. in thickness. Then, on some streets we see cobble and Belgian block. I would like to know the relative merits, and what results have been found in those experiments. Mr. Rice.

The Author.—In their first attempt to lay a pavement between the tracks, the company was delayed in their special work for several months, and the street became a nuisance, so the company went to the expense of about $40 000 in putting in a very light pavement, which was an asphalt mixture (not up to the grade of the first quality of asphalt), and that lasted, as they expected, only a few months. Then that was removed, and one of the paving companies substituted what they called their "Iron Clad Pavement." I do not know what the cost of that was. That lasted only about 6 or 8 months. Then that was taken out and the regular asphalt pavement laid. The asphalting between the rails is rather a new idea for New York. For heavy traffic it is not so good, but on the uptown streets it works all right. Of course, the granite is the more durable. But there are objections to granite. In the case of some of the older cable lines where granite was used between the rails, it has been necessary on very cold morn- The Author.

The Author. ings to reline the entire slot before cars could proceed. This was caused by the frost expanding the pavement and the pressure closing the slot.

Mr. Lewis. Mr. LEWIS.—I would like to ask Mr. Cudworth whether or not the Third Avenue Railroad, or the Metropolitan Railway, which is now in control, is using or is likely to use the recent Third Avenue Construction, placing wood between the rails and the yokes? I will also ask another question. You spoke of casting joints, and showed the operation of casting by hand. Is this method similar to the Falk "cast weld" joints?

The Author. The AUTHOR.—Yes, answering the last question first; it is the Falk "cast weld" joint.

As regards the Metropolitan Company continuing to use the Third Avenue construction, now that they are in control of the road, I do not think it at all probable that they will do so further than to use up the stock of material now on hand.

The Third Avenue construction is much lighter, and at the same time but little, if any cheaper, while it has some quite serious defects, especially in insulator box design. Again, the yokes are altogether too light for the strain that will be transmitted to them from the slot rail under the heavy downtown traffic.

Mr. Lewis. Mr. LEWIS.—As to the pavement between the tracks, I fail to see how you can put in stone pavement, so that it will last. The spaces to be paved are extremely small. In the case of the double slot construction which you have shown, there could scarcely have been a piece of pavement over 12 ins. in width. I don't know of anything better than asphalt for this kind of construction, though it may be quite expensive.

Can you give us any information as to the real efficiency of the wooden stringer under the rail?

The Author. The AUTHOR.—It has always struck me that the wooden stringer didn't amount to much. Where asphalt is laid it is completely covered up, and I have always thought that very little elasticity from that piece of timber was ever transmitted to the rail. The rail is embedded in concrete, almost entirely so, in the case of asphalt, while with granite, concrete comes up some 3 ins. above the base of the rail, as this concrete is brought up from the bottom of the conduit in one entire solid mass, completely embedding the stringer and a portion of the rail itself, holding them, as it were, in a grip of iron. It would seem to me impossible for that stick of timber to transmit any elasticity to the girder rail resting upon it, especially with this rail also embedded in the same mass of concrete.

In the double-slot construction we haven't used anything but asphalt that I know of. There is a piece of granite between the Grand Central Station and Madison Avenue which is the only piece of granite

that I know of in double-slot work. This was put down this present The Author.
season, the space between the slots and tram being 13¼ ins., while the depth next to slot is only 5½ ins., requiring a special block.

Mr. Lewis.—Upper Broadway, since it has been paved with asphalt, Mr. Lewis.
is about the handsomest specimen of a railroad street that I have ever seen. Though, of course, it is new, and looks particularly well just now.

The Author.—We cannot tell how long that is going to wear. The Author.
There is no reason why it should wear out very much faster than ordinary pavement. We tried last year to have the pavement slightly crowned—say, to have a half-inch crown between the rails, otherwise the roller would bear upon the top of the slot rail, and no pressure would be transmitted to the pavement; nearly all of our double slot pavement being put down with a 5-ton steam roller, no hand work being done.

Mr. Lewis.—Would the asphalt company give you any guarantee Mr. Lewis.
at all on pavements of that kind?

The Author.—I believe we have three years, at the price of $3.75. The Author.

Mr. Lewis.—Do you deduct the railroad spaces? Mr. Lewis.

The Author.—No. The Author.

Mr. Tillson.—The price mentioned would not cover the founda- Mr. Tillson.
tion?

The Author.—No; the foundation was laid by the company. The Author.

Mr. Provost.—I would like to ask if the figures given are for single Mr. Provost.
track?

The Author.—Single, in all cases. The Author.

Mr. Rice.—I would like to ask if you have any data as to the maxi- Mr. Rice.
mum energy which can be transmitted in a large duct?

The Author.—The Metropolitan Company are transmitting 6 600 The Author.
volts through a single cable. In Milwaukee I understand 20 000 volts are being sent successfully through a single duct. At St. Paul it is claimed 30 200 volts have been sent through a 3-mile cable.

Mr. Rice.—I would like to ask if Mr. Cudworth knows the insula- Mr. Rice.
tion resistance of this cable.

The Author: I do not. The Author.

Mr. Tillson.—I had occasion to examine the Third Avenue con- Mr. Tillson.
struction and the pavement between the rails while it was going on. The gridiron construction was made up in sections approximately 4 in. with the iron from ¾ to 1 in. in diameter, and it was made in such a way that a section through one of these wires would show alternately up and down at the corners (indicating). The concrete was laid 2 ins. below the top of the rail, and 1 in. of asphalt was laid on the concrete. Then the iron was placed upon that, and tamped down into it, then the remaining space was filled with asphalt. The high places at the corners of the iron were so high that when the asphalt was laid, there was not over ¼ of an inch, and in some places less, on top of the iron.

Mr. Tillson. So that when the traffic came on this it only had ¼ of an inch of asphalt on top of the iron to sustain it. And the asphalt wearing off came directly on the iron, and there was an uneven pressure, so that the iron would sink in one place and rise in another. That was the theory of the way it would act, and from the time the pavement lasted I think my conclusion was correct. I never could understand what the object was in laying this iron in the asphalt.

I think that the iron was really a detriment to the paving, and it would have lasted very much longer if it hadn't been there. Then. again, I think that where asphalt is used in street railway construction, it is much better to use the rock asphalt. That will stand more traffic than the asphalt that we use in this country ordinarily, and it is laid differently—it is tamped instead of rolled, so that you can get an even compression on it. If you want to crown a small space you can get any shape that you want, so that if it receives its ultimate compression which it will attain under traffic, then you can have somewhere near the pavement which you desire. I think that if they use the rock asphalt in place of the ordinary asphalt construction in this country, they would get very much better results.

The Author. The Author.—One thing which I think injured the asphalt pavement on Third Avenue was the spring under the rail. There was constant motion every time a heavy car went over it, the rail springing up and down.

Mr. Tillson. Mr. Tillson.—That certainly is one of the worst conditions you can get. You must have rigid construction—no motion at all.

Mr. Rice. Mr. Rice.—I noticed on the Boulevard these cast-iron joints, the place where they broke, about ⅜ of an inch, showing the contraction due to cold weather last winter. I would like to ask in practice for how long a distance they would make a continuous rail without providing for expansion or contraction.

The Author. The Author.—The original idea was to make a continuous rail from the Battery to Harlem—joints about 60 ft. apart. On our later construction on the Forty-second street work we put in expansion joints at the end of each piece of special work, so that we had no difficulty there with rails breaking. The Metropolitan Company on Lexington avenue have a continuous rail all the way down from One Hundred and Fifth street to Twenty-third street. Special work excepted. The longest continuous rail being Fifty-ninth to Eighty-sixth streets. They did the work at night. I think that is the way it should be done. On the Third Avenue construction it was done at any time. The work of casting joints would sometimes be done when the thermometer was at 85° F. At night the rail is comparatively cold, and when it is embedded in concrete for its entire length before the joint is made and the work done at night, there will be very little trouble from broken joints.

Mr. Lewis.—What percentage have failed? Mr. Lewis.

The Author.—The percentage was something like one-half of one per cent. up to last May, I think. The Author.

Mr. Tillson.—I was considerably interested in reading of the construction of the railway tracks in Sioux City where they used this continuous joint. There the greatest trouble arose in the construction when the full rail would be exposed to the sun where there is a diurnal variation of perhaps 40 or 50 degrees. In some of their construction they had wooden troughs made of boards placed over the rails to prevent the sun shining on them. Where these were not used the rails were covered with sand to prevent the action of the sun. In that way the construction was carried on with considerable of it exposed to the weather without any trouble at all, and it is said that afterwards they had no trouble, although it is very cold there—25 or 20° below zero nearly every winter. Of course, this theory of the electric joint, the welded joint was something that seemed to controvert all of our previous ideas of expansion and contraction; but, as I understand it, the generally accepted theory is now that so little of the rail is actually exposed to the sun and the atmosphere that there isn't more contraction and expansion in the rail than the elasticity of the metal will take up itself, and that is the explanation why there are not more failures such as Mr. Cudworth speaks of. Mr. Tillson.

I have noticed in one or two cases here in Brooklyn on the old Nassau lines, notably on Johnson avenue, where they have used that joint, where the track is considerably out of alignment at the present time, on account of expansion.

The Author.—I think that one cause of failure of the cast-welded joint is that the rail gets very hot at the point of contact. We thought that this was the reason for so many breaks in our Boulevard construction. That while the joint itself was very strong, the casting at such a temperature practically injured the metal of the rail and the strain was too much for it. In every case—I do not think we had more than three exceptions—the joint itself always broke 6 ins. one way or the other from the casting, usually breaking diagonally through the bolt holes, the rails being drilled for long fish-plates. The Author.

THE ANNUAL DINNER.

The Fifth Annual Dinner of the Club was held at the Oxford Club, Brooklyn, on Thursday evening, December 13th, 1900, at 7 o'clock.

George W. Tillson, President, acted as Toastmaster.

The sixty-eight members and guests present were welcomed in a graceful manner by Mr. F. Joseph Vernon, President of the Oxford Club, who responded to the toast "The Open Door."

Mr. Ludwig Nissen, President of the Manufacturers' Association of New York, in delivering a carefully prepared address "On the Firing Line," paid high compliment to the engineering profession for its achievements in advancing the progress of the world.

Mr. Nissen said in part: "We are on the firing line in diplomacy, industry and commerce. We are there in engineering science, which is practically the science that to-day is one of the first requisites to every enterprise in every walk of life. You cannot build nor operate a steamship or a railroad, nor any other vehicle of transportation without an engineer. You cannot run a large manufacturing plant without an engineer. You cannot conceive of any improvement in sanitary conditions anywhere without an engineer. You cannot build a road to walk on, nor a house to live in, nor a balloon to fly in without an engineer. You cannot get water into your house without an engineer, and in Brooklyn cannot even get it with the engineer. You cannot turn that water into beer, wine or whisky without considerable engineering. In other words, gentlemen, I want to have you interpret the idea in the most approved phraseology of the Bowery, that you are the "whole push." Our country is just now in that stage of development which is destined soon to make it the first in industry and commerce, the first in finance, the first in peace, the first in war and the first in the fears of all rivals. You should not forget, however, that individual character is the backbone of national prestige. Develop character by the education of all our citizens in the art of using the privileges and rights, and exercising the functions of a free suffragist. If we could make all our people appreciate the importance of and perform the sacred duties of their sovereign powers as freemen whether they have inherited them as a birthright or whether they have acquired them as a result of their ambition. This greatest and loveliest of all countries on earth will always be to the music of, and under the inspiration and guidance of, the Star Spangled Banner on the firing line.

Mr. Nelson P. Lewis, ex-President, spoke on "Under Currents," interspersing his address with many humorous stories.

Mr. Conlon led the singing in a number of general choruses, for which the string orchestra furnished the accompaniments.

The Entertainment Committee who had the dinner in charge also deserve much credit for the artistic *menu* cards, which were an interesting feature of the dinner.

THE JUNE DINNER.

The Third Annual Dinner to the Ladies was held at the Brighton Beach Hotel, on Thursday evening, June 14th, 1900, at 7 o'clock.

The special car, furnished by the courtesy of the Brooklyn Rapid Transit Co., conveyed the party from the Borough Hall and intermediate points to the Beach and return, and in spite of one of the heaviest rain-storms of the season which occurred just previous to the time of starting, the party numbered 67 members and guests.

The dinner was served in one of the private banquet rooms of the hotel with individual tables seating from four to twelve.

Willard S. Tuttle, Chairman of the Entertainment Committee, acted as Toastmaster.

President George W. Tillson responded to the toast "Engineers I have Met."

"The Ladies" was responded to by William G. Ford.

Joseph Strachan spoke on "Our Club Emblem," and James C. Meem on "A Word for the Hour."

Messrs. F. W. Perry, H. K. Landis, F. J. Conlon and J. C. Locke, the Club quartette, sang a number of songs, and Messrs. Locke and Conlon each contributed solos.

There were flowers for every one, and an especially large bouquet for Mrs. F. J. Conlon who played the accompaniments for the singers.

The meeting was voted a big success in spite of the rain and the Entertainment Committee received many congratulations on their efficient work.

MEMOIR OF PETER C. JACOBSEN.*

Died March 12th, 1900.

Peter Christian Jacobsen was born in the City of Copenhagen, Denmark, on June 8th, 1835.

He was a grandson of Count Christophersen, a General in the Danish Army.

Mr. Jacobsen was educated in the University of Copenhagen and served as a Lieutenant of Heavy Artillery in the war between Denmark and Prussia.

He came to the United States in 1863 and engaged in business for himself as a carpenter and builder until 1879, when he entered the employ of Wm. D. Andrews & Bro., of New York, and was in charge until 1893 of all work done by them, which included a large amount of driven well work done for the City of Brooklyn.

In July, 1893, he left the employ of Wm. D. Andrews & Bro., and engaged for some time in contract work on his own account, mainly the construction of driven well plants for manufacturing concerns.

During the early part of 1894 he was appointed Inspector of Driven Wells in the Department of City Works of the then City of Brooklyn, and continued in that position until the time of his death, which was due to pneumonia, contracted while in the discharge of his duties.

The effect of his early military training was apparent in all of Mr. Jacobsen's work ; he was careful, exact and methodical in all that he did.

All who came in contact with him were impressed with the completeness of his knowledge of the details of the driven well work, of which he had made a special study for many years.

Never arrogant or overbearing, he maintained a thorough discipline among his subordinates, who thus showed their great respect for the man and their perfect confidence in his judgment.

He will long be remembered as a genial, kindly and true man by those who knew him.

* From family records and by J. Strachan, Member of B. E. C.

Peter C. Jacobsen.

LIST OF BOOKS TO BE FOUND IN THE LIBRARY

OF THE

BROOKLYN ENGINEERS' CLUB.

CIVIL ENGINEERING AND ARCHITECTURE.

Adams, Fred'k W	Atmospheric Resistance to Railway Trains, 1892.
Adams, Henry	Strains in Ironwork, 1888.
	Practical Designing of Structural Ironwork, 1894.
Allsop, Robt. O	Public Baths and Washhouses, 1894.
Aitken, Thos	Road Making and Maintenance, 1900.
Ashby, Holdon M	How to Analyze Clay, 1898.
Baker, B	Strengths of Beams and Arches, 1870.
Baker, Ira O	Masonry Construction, 1895.
Baker, M. N	Sewerage and Sewage Purification, 1896.
	The Manual of American Water-Works, 1897.
	Potable Waters and Methods of Detecting Impurities, 1899.
Bailey-Denton, E	Sewage Purification, 1896.
Baldwin, W. J	Steam Heating for Buildings, 1881.
	Ventilation and Warming, 1899.
Bale, M. P	Stone-Working Machinery, 1884.
Bancroft. R. M. and F. J.	Tall Chimney Construction, 1885.
Banner, E. G	Wholesome House, 1882.
Barrois, J	Irrigation in Egypt for 1889.
Barwise, Sidney	Purification of Sewage, 1899.
Baumeister, R	Cleaning and Sewerage of Cities, 1891.
Bell, T. J	History of Water Supply, 1882.
Berg, L. De C	Safe Building, Vol. I, 1894.
	Safe Building, Vol. II, 1892.
Berg, Walter G	Buildings and Structures of American Railroads, 1893.
Billings, Jno. S	Ventilation and Steam Heating, 1884.
Bird, F. W	The Hoosac Tunnel, 1865.
Birkmire, W. H	Skeleton Construction in Buildings, 1894.
	Compound Riveted Girders, 1896.
	Planning and Construction of High Office Buildings, 1898.
Birkmire, W. H	Architectural Iron and Steel.
Bjorling, P. R	Pumps, 1890.
Blake, E. T	Sewage Poisoning.
Boulnois, H. P	Dirty Dust Bins and Sloppy Streets, 1881.
Bow, R. H	Economics of Construction (Framed Structures), 1893.
Box, Thos	Strength of Materials, 1893.
Broom, Geo. J. C	Drainage and Disposal of Town Sewage, 1889.
Brooks, John P	Handbook Street Railroad Location, 1898.
Brown, G. P	Sewer Gas and Its Dangers, 1881.
Briggs, Robt	Steam Heating, 1888.
Buckley, E. R	Building and Ornamental Stones.
Burr, S. D. V	Tunnelling under the Hudson River, 1885.

Burr, Wm. H.	Elasticity and Resistance of Materials, 1883.
Burton, F. G.	Engineering Estimates and Cost Accounts, 1896.
Burton, W. K.	Water Supply of Towns, 1894.
Burke, M. D.	Brick for Street Pavements, 1894.
Butler, D. B.	Portland Cement, 1899.
Byrne, A. T.	Highway Construction, 1893.
	Inspection of Materials, 1898.
Cain, Wm	Maximum Stresses in Framed Bridges, 1897.
Carpenter	Experimental Engineering, 1895.
Carpenter, R. C.	Heating and Ventilating Buildings, 1895.
Carson, Howard	Metropolitan Sewerage System, "Technology Quarterly," 1893.
Cassanbrait	Engineering and Architectural Jurisprudence, 1898.
Clarke, D. K.	Tramways—Their Construction and Working, Vol. I, 1878.
	Tramways—Their Construction and Working, Vol. II, 1882.
Clarke, E. C.	Main Drainage Works of Boston, 1885.
Clarke, Bogert *et als*	The American Railway, 1889.
Clarke, G. S.	The Principles of Graphic Statics, 1880.
Clarke, T. M.	Architect, Owner and Builder Before the Law, 1894.
Codington, T.	The Maintenance of Macadamized Roads, 1892.
Coffin, Freeman C.	Hydraulic Problems, 1897.
Collett, Harold	Water Softening and Purification, 1895.
Coleman, J. E.	Stable Sanitation and Construction, 1898.
Colyer, Fred'k	Water Supply and Drainage, 1889.
	Pumps and Pumping Machinery, 1882.
Conant and Schuyler	The Brooklyn Bridge.
Crimp, W. Santo	Sewage Disposal Works, 1894.
Cummings, Uriah	American Cements, 1898.
Dahlgren	Laws New York Building Department.
Davies, P. J.	Practical Plumbing, Vol. I, 1889.
	Practical Plumbing, Vol. II, 1896.
Daubuisson	Hydraulics. 1852.
Derr, Wm. L.	Block Signal Operation, 1897.
De Varona, A.	Sewer Gases, 1879.
De Varona, I. M.	Future Extension of Brooklyn Water Supply, 1896.
	Brooklyn Water Supply, 1896.
Dibdin, W. J.	Purification of Sewage and Water, 1897.
Dolman, F.	Municipalities at Work, 1895.
Drysdale & Hayward	Health and Comfort in House Building, 1890.
Duane, James C.	The New Croton Aqueduct, 1887 to 1895—1895.
Du Bois, A. J.	The Stresses in Framed Structures, 1896.
Dye, F.	Hot Water Supply, 1887.
Dye & Hood	Warming Buildings by Hot Water, 1891.
Egbert, Seneca	Manual of Hygiene and Sanitation, 1898.
Engineering Record	Prize Essays, Road Construction and Maintenance, 1892.
Engineer's Reports	East River Bridge, 1885.
Engineering News	Manual of American Water-Works, 1888.
	Manual of American Water-Works, 1891.
	Manual of American Water-Works, 1897.
Faija, H.	Portland Cement for Users, 1881.
Fairchild, C. B.	Street Railways, 1892.
Fanning, J. T.	Water Supply Engineering, 1877.
	Water Supply Engineering, 14th Edition, 1899.
Fidler, T. Claxton	Calculations in Hydraulic Engineering, Part I, 1898.
FitzGerald. Desmond	Boston Water-Works, 1895.
Fitzmaurice, Maurice	Plate Girder Railway Bridges, 1895.
Flynn, P. J.	Flow of Water in Channels, etc., 1886.
	Hydraulic Tables, 1883.
Folwell, A. P.	Sewerage Systems, 1898.
	Water Supply Engineering, 1900.

Foster, Horatio A.........Central Station Bookkeeping, 1894.
Foster, Walcott C.........Treatise on Wooden Trestle Bridges, 1897.
Fowler, Chas. E...........Coffer-Dam Process for Piers, 1898.
Freeman, John R.........New York Water Supply, 1900.
Freitag, J. K..............Fireproofing of Steel Buildings, 1899.
Freitag, J. K..............Architectural Engineering, 1895.
Frith, Henry..............The Triumphs of Modern Engineering.
Fuertes.....................Water and Public Health, 1897.
Fuller, Geo. W............Purification of Ohio Water at Louisville, 1898.
Ganguillet and Kutter....Flow of Water, 1893.
Gerhard, Wm. Paul.......The Disposal of Household Wastes, 1890.
Sanitary Drainage of Buildings, 1890.
Drainage and Sewerage of Dwellings, 1892.
House Drainage and Sanitary Plumbing, 1894.
Gas Lighting and Gas Fitting, 1894.
Sanitary House Inspection, 1895.
Miscellaneous Essays.
Gerhard, Wm. Paul.......Sanitary Engineering, 1898.
Regulations for Drainage, Water Supply, Fire Protection, etc. N. Y. Lunacy Com., 1899.
Sanitary Engineering of Buildings, 1899.
Gillespie, W. M............A Manual of Road Making, 1847.
Gillespie, T. A. Co........Riveted Steel Water Pipes, 1897.
Gilmore, Q. A.............Building Stones, 1876.
Treatise on Limes, Cements, etc., 1888.
Goodell, John.............Water-Works for Small Cities and Towns, 1899.
Goodhue, W. F............Municipal Improvements, 1893.
Gould, E. Sherman........High Masonry Dams, 1897.
Water Supply Engineering, 1899.
Goulds Mfg. Co...........Pumps and Hydraulic Machinery.
Graether. L. F.............Buildings Laws, City of New York, 1898.
Gratz, M....................Terminal Facilities, Port of New York, 1885.
Gray, Saml. M.............Sewerage of Cities (Providence Report), 1884.
Greaves.....................Elementary Hydrostatics, 1894.
Greene, Chas. E...........Trusses and Arches, 1894.
Greene, Chas. E...........Roof Trusses, 1888.
Greene, Chas. E...........Bridge Trusses, 1888.
Greenwell & Curry........Rural Water Supply, 1896.
Haldane, J. W. C..........Civil and Mechanical Engineering, 1890.
Hall, W. E..................Car Lubrication, 1895.
Hancock, H...............Mechanics and Hydrostatics, 1894.
Hart, J. W................Hints to Plumbers, 1893.
Hatfield, R. G.............Transverse Strains, 1877.
The American House Carpenter, 1895.
Haupt, Lewis M...........A Move for Better Roads, 1891.
Engineering Specifications.
Haupt, Herman...........Street Railway Motors, 1893.
Hazen, Allen ....Filtration of Public Water Supplies, 1895.
Hedges, K..................American Electric Street Railways, 1894.
Hellyn, J. S.................Sanitary Plumbing, 1882.
Herschel, Clemens........115 Experiments, 1897.
Hervieu, Jules............Traité Practique de la Construction des Egouts, 1898.
Higham, T.................Hydraulic Tables, 1898.
Hildenbrand, W...........Cable Making for Suspension Bridges, 1877.
Hill, Jno. W...............Purification of Public Water Supplies, 1898.
Hill, Chas. S...............Chicago Main Drainage Canal, 1896.
Hiroi, Isami...............Plate Girder Construction, 1893.
Holley, Alex. L...........American and European Railway Practice, 1861.
Howe, M. A................Retaining Walls for Earth, 1896.

Hueppe, Dr. F............Principles of Bacteriology, 1899.
Humber, W...............Water Supply of Cities and Towns, 1876.
Hurst, G. H.............. Painters' Colors, Oils and Varnishes, 1892.
Hurst, Jno. T.............Formulæ, Tables, etc., 1882.
Hutton, Wm. R...........The Washington Bridge, 1889.
Jacob-Gould...............Storage Reservoirs, 1888.
Jameson, Chas. D.........Portland Cement, 1898.
Jenkin, Fleming..........Heating Houses, 1879.
Johnson, F. R.............Stresses in Girder and Roof Trusses, 1894.
Johnson, J. B.............Engineering Contracts and Specifications, 1895.
The Materials of Construction, 1897.
Johnson, Bryan & Turneaure...................Theory and Practice of Modern Framed Structures, 1896.
Jones, Chas...............Refuse Destructors, 1894.
Jones, Robt. H............Asbestos and Asbestic, 1897.
Jones, Walter.............Heating by Hot Water, 1896.
Judson, Wm. P............City Roads and Pavements, 1894.
Keating, J. M..............The Yellow Fever Epidemic of 1878 in Memphis, 1879.
Kelton, D. H..............History of Sault Ste. Marie Canal, 1888.
Kent, W. G................The Water Meter, 1892.
Kent, Wm.................Kent's Mechanical Engineers' Pocket-Book, 1895.
Wrought Iron and Chain Cables, 1879.
Kensington School........Notes on Building Construction, Part II, 1876.
Kensington School........Notes on Building Construction, Part III, 1879.
Notes on Building Construction, Part IV, 1891.
Kidder, Frank E..........Architects and Builders' Pocket-Book, 1897.
Building Construction and Superintendence, Part I, 1898.
Building Construction and Superintendence, Part II, 1899.
Kiersted, Wynkoop.......Sewage Disposal, 1894.
Killingworth, Hedges.....American Electric Street Railways, 1894.
Kindl, F. H................Carnegie's Pocket Companion, 1893.
King, Chas................Croton Aqueduct, Cost, Capacity, etc., 1843.
King, F. H.................Irrigation and Drainage, 1899.
Kirkwood, James P.......Brooklyn Water-Works and Sewers, 1867.
Krantz, J. B...............Reservoir Walls, 1883.
Lanza, Gaetano...........Applied Mechanics, 1896.
La Rue, Benj..............A Graphical Method for Swing Bridges, 1892.
Lawler, Jas. J.............Hot Water Heating, Steam and Gas Fitting, 1895.
Leffel, Jas. & Co..........Construction of Mill Dams, 1874.
Contruction of Mill Dams, 1881.
Leverich, G...............Cable Railway on Brooklyn Bridge, 1888.
Traffic Capacity of Brooklyn Bridge, 1889.
Lewis, Fredk. H..........European Cement Industry, 1899.
Luce, Robt................Electric Railways, 1886.
Martin, C. A...............Details of Building Construction, 1899.
Mason, Wm. P.............Examination of Water, Chemical and Bacteriological, 1899.
Mason, W. P...............Water Supply, 1896.
Matheson, E...............Matheson's Aid Book, 1889.
Maxwell, Wm. H..........Removal and Disposal of Town Refuse, 1898.
McCain, C. C..............Compendium of Transportation Theories, 1893.
McElroy, Saml...........Hempstead Storage Reservoir, 1878.
McMaster, J. B............Bridge and Tunnel Centers, 1875.
Merchants Assoc, N. Y....Report on Water Supply of New York, 1900.
Merriman & Jacoby.......Roofs & Bridges, Part I (Stresses), 1898.
Roofs and Bridges, Part II (Graphic Statics), 1897.
Roofs and Bridges, Part III (Bridge Design), 1898.
Roofs and Bridges, Part IV (Higher Structures), 1898.
Merriman, Mansfield......The Mechanics of Materials, 1885.
The Strength of Materials, 1898.

Merriman, Mansfield......Sanitary Engineering, 1898.
Merriwether, Niles........Statements and Estimates of Pavements and Sewers, etc.
Metropolitan Sewerage Commission.............Sixth Annual Report, Mass., 1895.
Seventh Annual Report, Mass., 1896.
Meyer, Henry C...........Water Waste Prevention, 1885.
Molesworth, G. L.........Pocket-Book for Civil and Mechanieal Engineers, 1899.
Moore, E. C. S.............Sanitary Engineering, 1898.
Mott, Henry A., Jr........Ventilation, 1883.
Nagle, J. C.................Field Manual for Railroad Engineers, 1897.
Newell, F. H...............Agriculture by Irrigation, 1894.
Newman, Jno...............Cylinder Bridge Piers, 1893.
Newman, Jno...............Notes on Concrete, 1894.
Metallic Structures, Corrosion and Fouling, 1896.
Newsholme, Arthur.......Vital Statistics, 1899.
Nicolls, Wm. J............The Railway Builder, 1897.
Nichols, Wm. R...........Water Supply, 1894.
Nourse, J. E...............Maritime Canal of Suez, 1884.
North, Edw. P.............Construction and Maintenance of Roads.
N. Y. R. R. Commission..Report on Bridge Strains, 1891.
Ogden, H. N...............Sewer Design, 1899.
Palmberg, Albert ....Treatise on Public Health, 1893.
Parsons, W. B.............Track, 1886.
Paterson, M. McC.........Testing of Pipes and Pipe-Joints, 1879.
Patton, W. M..............A Treatise on Civil Engineering, 1895.
A Practical Treatise on Foundations, 1895.
Pearce, W. J..............Painting and Decorating, 1898.
Pinchot and Graves.......The White Pine, 1896.
Plympton, G. W...........Van Nostrand's Civil and Mechanical Engineers' Table Book 1892.
How to Become an Engineer, 1891.
Poncelet and Woodbury ..Sustaining Walls, 1854.
Pratt & Alden.............Street Railway Roadbed, 1898.
Prudden, T. M.............Drinking Water and Ice Supplies, 1891.
Rafter, Geo. W............Microscopical Examination of Potable Water, 1892.
Mechanics of Ventilation, 1896.
Rafter and Baker.........Sewage Disposal in the United States, 1894.
Rankine, W. J. M.........Manual of Civil Engineering, 1865.
Rules and Tables, 1867.
Redgrave, G. R............Calcareous Cements, 1895.
Reid, Henry................A Practical Treatise on Concrete, 1879.
Reynolds, Michael ....Continuous Railway Brakes, 1882.
Rideal, Samuel............Water and its Purification, 1897.
Sewage and the Bacterial Purification of Sewage, 1900.
Robinson, Henry..........Hydraulic Power and Machinery, 1887.
Sewage and Sewage Disposal, 1896.
Robinson, S. W............Strength of Wrought-Iron Bridge Members, 1882.
Rockwell, A. P............Roads and Pavements in France, 1896.
Roebling, W. A............Pneumatic Tower Foundations of East River Bridge, 1872.
Ruffner, E. H..............Improvement of Non-Tidal Rivers, 1885.
Sachs, E. O................Fires and Public Entertainments, 1897.
Scott, Jno..................Irrigation and Water Supply, 1883.
Scranton School...........Building Trades Pocket Book, 1899.
Searles, Wm. H...........Field Engineering, 1891.
Shadwell, A...............London Water Supply, 1899.
Shaler, N. S...............American Highways, 1896.
Siebert & Biggin..........Modern Stone Cutting and Masonry, 1896.
Slagg, Chas...............Water Engineering.
Smead, Isaac D............Ventilation and Warming of Buildings, 1889.

meatcn, Jno.............Plumbing, Drainage, Water Supply, 1893.
Smith, Hamilton, Jr......Hydraulics, 1886.
Spalding, Fred. P.........Roads and Pavements, 1894.
Hydraulic Cement, 1897.
Spencer, Jas. C...........The New Croton Aqueduct, 1883 to 1887.
Spennrath, J.............Protective Coverings for Iron, 1896.
Spinks, W.................House Drainage Manual, 1897.
Spon, Ernest.............Sinking and Boring Wells, 1885.
Staley and Pierson........Separate System of Sewerage, 1891.
Statistics, U. S............Statistics of Railways in the United States, 1894.
Stevenson, David..........Canal and River Engineering, 1872.
Stone, Roy................New Roads and Road Laws, 1894.
Sutro, Tunnel Commission. The Sutro Tunnel, 1872.
Sutro, Theodore...........The Sutro Tunnel, 1887.
Swan and Horton.........Hydraulic Diagrams, 1899.
Sylvester, W. A...........Modern Carpentry and Building, 1896.
Terry, Geo................Pigments, Paint and Painting, 1893.
Thurston, R. H............Materials of Construction, 1885.
Materials of Engineering, Part I, 1883.
Tillson, Geo. W............Street Pavements and Paving Materials, 1900.
Tratman and Fernow.....Use of Metal Railroad Ties, 1894.
Metal versus Wooden Ties, 1890.
Trautwine, J. C...........Curves, 1886.
Engineers' Pocket-Book, 1889.
Turner and Brightmore...Water-works Engineering, 1893.
Unwin, Wm. C............Testing of Materials of Construction, 1899.
U. S. Government.........Test of Metal, 1886.
U. S. Government.........Stream Measurements for 1896.
Vermeule, C. C............Water Supply of New Jersey, Report 1894.
Vernon-Harcourt, L. F...Rivers and Canals, Vol. I, 1882.
Rivers and Canals, Vol. II, 1882.
Achievements in Engineering, 1891.
Vose, Geo. L..............Manual for Railroad Engineers, 1873.
Bridge Disasters in America, 1887.
Voss, Wm..................Railway Car Construction, 1892.
Waddell, J. A. L..........Pocket-Book for Bridge Engineers (De Pontibus), 1898.
Wait, J. C.................Engineering and Architectural Jurisprudence, 1898.
Walker, T. A..............The Severn Tunnel, 1888.
Wallace, W. W., Jr........Brick Pavements, 1895.
Wanklyn and Cooper.....Sewage Analysis, 1899.
Waring, Geo. E., Jr.......Village Improvements, 1877.
Final Disposition of the Wastes of New York, 1896.
Sewerage and Land Drainage, 1891.
Sewage Disposal, 1894.
Sanitary Drainage of Houses and Towns, 1878.
How to Drain a House, 1885.
Wegmann, E., Jr..........Masonry Dams, 1893.
The Water Supply of New York, 1896.
Weisbach, Julius..........Mechanics of Engineering, Vol. I, 1872.
Wellington, A. M..........Economic Theory of Railway Construction, 1891.
Weston, E. B..............Loss of Head in Pipes (Tables), 1896.
Weyrauch, P. J...........Structures of Iron and Steel, 1891.
Wheeler, W. H............Tidal Rivers, 1893.
Whipple, Geo. C..........Microscopy of Drinking Water, 1899.
Wilcox, Lute..............Irrigation Farming, 1895.
Wilcox, R. M..............Cantilever Bridges, 1898.
Williamson, Benj..........Stress and Strain of Elastic Solids, 1894.
Wilson, H. M..............Irrigation Engineering, 1893.
Wilson, G.................Hand Book of Hygiene and Sanitary Science, 1898.

Wolff, A. R................Ventilation of Buildings.
Wood, De Volsom.........The Resistance of Materials, 1875.
Wolheim, Albert..........Sewerage Engineers' Note Book, 1896.
Wright, A. W.............American Street Railways, 1888.
Wright, Chas. H..........The Designing of Draw Spans, 1897.

MECHANICAL ENGINEERING.

Abbott, A. V..............Treaties on Fuel, 1891.
Adams, Henry............Handbook for Mechanical Engineers, 1891.
Alexander, J..............Model Engine Construction, 1894.
Anderson, Wm............Conversion of Heat into Work, 1887.
Armstrong, R.............Chimneys for Furnaces and Boilers, 1883.
Steam Boilers, 11th Edition, 1892.
Babcock & Wilcox........Steam (Trade Publication), 1891.
Bale, M. P................ Saw Mills, Arrangements and Management, 1883.
Modern Shafting and Gearing, 1893.
Ball, R. S...................Theory of Screws, 1900.
Barr, Wm. M..............Boilers and Furnaces, 1898.
Bjorling. Ph. R............Water, or Hydraulic Motors, 1894.
Black, John...............Gas Fitting, 1886.
Blaine, R. G...............Hydraulic Machinery, 1897.
Bolland, S..................Encyclopædia of Founding, 1894.
Bolton, Reginald P........Motive Powers and their Practical Selection, 1895.
Brannt, Wm. T............Petroleum and Natural Gas, 1895.
Campin, F......... ....Hand Turning, 1883.
Chanute, O.................Progress in Fying Machines, 1894.
Carpenter, R. C...........Experimental Engineering, 1895.
Christie, Wm. W..........Chimney Design and Theory.
Clarke. D. K...............Manual for Mechanical Engineers, 1878.
Fuel, Its Combustion and Economy, 1891.
The Steam Engine, 4 vols., 1890.
Clerk, Dugald... ....Gas and Oil Engines, 1896.
The Gas Engine, 1886.
Colburn, Zerah............Steam Boiler Explosions, 1873.
Colyer, Fred..............Gas Works: Arrangement and Construction, 1884.
Pumps and Pumping Machinery, 1882.
Crew, Benj. J.............Practical Treatise on Petroleum, 1887.
Cripps, F. Southwell......Gas Holders and Tank Construction, 1898.
Dahlstrom, Karl P.........The Fireman's Guide, 1891.
Davis, C. T.................Treatise on Manufacture of Brick, 1884.
Davies, Jas.................Galvanized Iron, Manufacture and Use, 1899.
Deerr, Noël.................Sugar House Notes and Tables, 1900.
Diesel, Rudolph...........Rational Heat Motor, 1894.
Donkin, B., Jr..............Gas, Oil and Air Engines, 1894.
Dubois & Weisbach.......Mechanics of Engineering and Cost of Machines, 1878.
Durand, Wm. F...........Resistance and Propulsion of Ships, 1898.
Ewing, J. A................Steam Engines and other Heat Engines, 1894.
Fijuje, van Salruda.......Aerial Navigation, 1894.
Flather, J. J...............Rope Driving, 1895.
Fletcher, Wm..............The Steam Jacket, 1895.
Fletcher, Thomas.........Commercial Uses of Coal Gas.
Flower, P. W ....History of Tin and Tin Plate, 1880.
Fuller, John...............Art of Coppersmithing, 1894.
Fulton, John..............Coke Manufacture and By-Products, 1895.
Gaisford & Langmaid.....Steam Machinery and the Marine Engine, 1893.
Galloway, Robt...........Treatise on Fuel, 1880.
Gibbs, Wm. E.............Lighting by Acetylene, 1898.

Goodeve, T. M............On Gas Engines, 1887.
Steam Engine, Gas Engine and Heat Engine, 1896.
Greenwood, W. H.........Steel and Iron, 1884.
Grimshaw, Robt..........Grimshaw on Saws, 1880.
Steam Engine Catechism, 1889.
Hints to Power Users, 1891.
Hartley, F. W.............Gas Measurement and Gas Meter Testing, 1882.
Hastings, Chas. W........Gas Works Statistics, 1885.
Haswell, Chas. H..........Mechanics and Engineers' Pocket-Book, 1898.
Henthorn & Thurber.....The Corliss Engine, 1894.
Herman & Weisbach......Mechanics of Hoisting Machinery, 1893.
Mechanics of Engineering and Machinery, 1883.
Hiorns, A. H..............Iron and Steel Manufacture, 1889.
Hiscox, G. D..............Mechanical Movements, 1899.
Gas, Gasoline and Oil Vapor Engines, 1898.
Holmes, Geo. C. V........The Steam Engine, 1887.
Marine Engines and Boilers, 1889.
Hornby, John.............Gas Engineers' Laboratory Hand-Book, 1894.
Horner, Jas. G............English and American Lathes, 1900.
Hovenden, Fred...........What is Heat, 1894.
Hughes, Geo..............Construction of the Modern Locomotive, 1894.
Hurst, Geo. H.............Lubricating Oils, Fats and Greases, 1896.
Hutton, F. R..............Mechanical Engineering of Power Plants, 1897.
Heat and Heat Engines, 1899.
Hutton, W. S..............Steam Boiler Construction, 1898.
Innes, Chas. H............Centrifugal Pumps, Turbines, etc., 1899.
Jeams, J. S................Steel, Its History, Manufacture, etc., 1880.
Kennedy, A. B. W.........Compressed Air, 1892.
Kinealy, J. H..............Steam Engines and Boilers, 1895.
Klein, J. F.................Elements of Machine Design, 1889.
Langmaid & Gaisford.....Steam Machinery and the Marine Engine, 1893.
Leash, A. R...............Triple Expansion Engines and Boilers, 1892.
Breakdowns at Sea and How Repaired, 1894.
Refrigerating Machinery and Management, 1895.
Ledoux, M................Ice-Making Machines, 1879.
Levan, Wm. B.............Management of Engines and Boilers, 1897.
Lewis, J. S................Commercial Organization of Factories, 1896.
Lewes, Virian B...........Acetylene, Hand-Book for Students and Manufacturers, 1900.
Lockert, Louis............Petroleum Motor Cars, 1898.
Lieckfeld, G...............Gas and Oil Engines, 1896.
Lukin, J....................Turning Lathes, 1890.
MacCord, Chas W.........Kinematics or Mechanical Movements, 1883.
Marks, Wm. D............The Steam Engine, 1889.
Martin, E. A...............Story of a Piece of Coal, 1896.
Metcalf, Wm...............Steel, 1896.
Meyer, J. G. A.............Mechanical Drawing and Mechanical Design, Vol. I, 1898.
Millis, C. T................Metal Plate Work, 1893.
Molesworth, G. L.........Pocket-Book for Mechanical and Civil Engineers, 1899.
Monroe, R. D............. Steam Boilers, Management and Construction, 1887.
Müller, F. C. G............Krupp's Steel Works, 1898.
Mullin, J. P................Modern Moulding and Pattern-Making, 1885.
Newbegging, Thos........Gas Engineers and Managers' Hand-Book, 1898.
Nichols, Wm. J............Story of American Coals, 1897.
Nichols, Wm. J............Coal Catechism, 1898.
O'Connor, H...............Gas Engineers' Pocket-Book, 1898.
Overman, Fred'k..........Mechanics for Millwright, Engineer, etc., 1867.
Parry, Leonard A.........Risks and Dangers of Various Occupations, 1900.
Peabody, Cecil H.........Thermodynamics of the Steam Engine, 1890.
Peabody & Miller..........Steam Boilers, 1897.

Phillips, H. J..............Fuel, Solid, Liquid and Gaseous, 1896.
Phillips & Prochaska.....Basic Bessemer Process, 1891.
Pickworth, C. N...........The Indicator Hand-Book, 1898.
Poole, H....................Calorific Power of Fuels, 1898.
Preston, Thos.............The Theory of Heat, 1894.
Rand, Addison C..........Uses of Compressed Air, 1894.
Rankine, Wm. J. M.......Mechanical Text Book, 1873.
Cyclopædia of Machine and Hand Tools, 1869.
Applied Mechanics, 1869.
Machinery, and Mill Book, 1869.
Manual of the Steam Engine, 1861.
Raymond, J. H............Report on Illuminating Gas, 1883.
Reagan, H. C., Jr.........Locomotive Mechanism and Engineering, 1894.
Redwood, J. I.............Ammonia Refrigeration, 1895.
Lubricants, Oils and Greases, 1898.
Reynolds, Micah..........Stationary Engine Driving, 1882.
Reynolds, Osborne........Triple Expansion Engines, etc., 1890.
Richards...................Centrifugal Pumps.
Rideal, Samuel............Glue and Glue Testing, 1900.
Ripper, Wm...............Steam Engine Theory and Practice, 1899.
Robinson, Henry..........Hydraulic Power and Hydraulic Machinery, 1887.
Robinson, Wm............Gas and Petroleum Engines, 1890.
Roper.........................Engineers' Hand-Book, 15th edit.
Rose, Joshua..............Modern Steam Engines, 1886.
Modern Machine Shop Practice, 2 vols., 1888.
Steam Boilers, 1889.
Rowan, F. J................Boiler Incrustation and Corrosion, 1876.
Rowan, Thos..............Coal, Spontaneous Combustion, 1882.
Seaton, A. E..... ,........Manual of Marine Engineering, 1883.
Sennett, Rich'd............The Marine Steam Engine, 1882.
Sharp, John...............Modern Foundry Practice, 1900.
Smith, J. B.................Treatise on Wire Manufacture and Uses, 1891.
Spencer, Adam............Roll Turning, 1894.
Spon, E. & F. M...........Spon's Mechanic's Own Book, 1885.
Stahl, A. W.................Transmission of Power by Wire Ropes, 1893.
Sturtevant, B. F..........Mechanical Draft, 1898.
Ventilation and Heating, 1899.
Sutcliffe, Geo. W..........Steam Power and Mill-Work, 1895.
Tait, P. T...................Heat, 1884.
Tennant, W. J.............The Slide Valve, 1899.
Thompson, G. F...........Acetylene Gas and Calcium Carbide, 1898.
Thurber & Henthorn......The Corliss Engine, 1894.
Thurston, Robt. H........Friction and Lost Work in Machine and Mill-Work, 1891.
Heat as a Form of Energy, 1890.
History of Growth of Steam Engine, 1878.
Tower, G. B. N............Useful Things About Steam Boilers, 1885.
Tyndall, John.............Heat as a Mode of Motion, 1883.
Unwin, Wm. C............Development and Transmission of Power from Central Station, 1894.
Elements of Machine Design, 1877.
Van Salruda...............Aerial Navigation, 1894.
Wallis-Taylor, A. J........Refrigerating and Ice-Making Machinery, 1896.
Aerial or Wire-Rope Tramways, 1898.
Watson, E. P..............How to Run Engines and Boilers, 1892.
Walft, Alfred R...........Wind Mills, 1885.
Weisbach & Hermann....Mechanics of Hoisting Machinery, 1893.
Mechanics of Engineering and Machinery, 1883.
Weisbach & Dubois.......Mechanics of Engineering and Construction of Machines, Vol II, 1878.

West, T. D................American Foundry Practice, 1882.
American Foundry Practice, 9th Edition, 1897.
Wilson, W. H..............Pattern Making and Moulding, 1894.
Wolff, A. R................Wind Miils, 1885.
Wood, De Volson.........The Theory of Turbines, 1895.
Thermodynamics, Heat Motors and Refrigerating Machines, 1891.
Woolcombe, W. G.........Heat, 1893.
Worthen, Wm. E..........Appleton's Cyclopædia of Technical Drawing, 1898.
Wright, Mark R...........Heat, 1893.
Yea, John.................Steam and the Marine Engine, 1894.
Zahner, Robt..............Transmission of Power by Compressed Air, 1878.

ELECTRICAL ENGINEERING.

Abbott, A. V..............Electrical Transmission of Energy, 1895,
Allsop, F. C...............Induction Coils and Coil Making.
Practical Electric Bell Fitting, 1895.
Practical Electric Light Fitting, 1893.
Telephones, Their Construction and Fittings, 1891.
Anderson, Rich'd.........Lightning Conductors, 1879.
Atkinson, Phillip..........Elements of Dynamic Electricity and Magnetism, 1891.
Electric Transmission of Power, 1893.
Electricity for Everybody, 1895.
Electric Lighting, 1888.
Atwood, L. C..............Practical Dynamo Building, 1893.
Badt, F. B.................Dynamo Tenders' Hand-Book, 1891.
Electric Transmission Hand-Book, 1891.
Bedell, Fred'k.............Principles of the Transformer, 1896.
Bedell & Crehore..........Alternating Currents, 1893.
Benjamin, Park............The Voltaic Cell, 1893.
Intellectual Rise in Electricity, 1895.
The Age of Electricity, 1889.
Berly.........................Reynier's Voltaic Accumulator.
Bonney, G. E..............Induction Coils, 1892.
Electrical Experiments.
Electro Platers' Hand-Book, 1894.
Bottone, S. R..............The Dynamo, How Made and How Used, 1884.
Electric Bells and All About Them, 1889.
Guide to Electric Lighting, 1892.
Brackett, O. F. *et al*......Electricity in Daily Life, 1891.
Caillard, E. M............Electricity, 1891.
Carhart, H. S..............Primary Batteries, 1891.
Carter, E. T...............Motive Power and Gearings for Electric Machinery, 1896.
Carus-Wilson, C. A.......Electro-Dynamics—Direct Current Motors, 1898.
Cox, F. P..................Continuous Current Dynamos and Motors, 1893.
Crocker, F. B..............Electric Lighting, 1896.
Crocker & Wheeler........Management of Dynamos and Motors, 1894.
Crosby & Bell............The Electric Railway, 1892.
Curry, C. E...............Theory of Electricity and Magnetism, 1897.
Cushing, H. C., Jr.........Standard Wiring for Electric Light and Power, 1896.
Davis, C. M................Standard Tables for Electric Wiremen, 1893.
Davis & Howell...........Third Rail Electric Traction.
Desmond, Chas............Electricity for Engineers, 1890.
Dredge, Jas. *et al*.........Electric Illumination, Vol. I, 1882.
Electric Illumination, Vol. II, 1885.
Du Moncel, T..............Electricity as a Motive Power, 1883.
Dubois, H...................The Magnetic Circuit, 1896.

Elliott, A. G	Industrial Electricity, 1898.
Emtage, W. T. A	Electricity and Magnetism, 1891.
Fahie, Angelo	House Lighting by Electricity, 1892.
Faraday, Michael	Experimental Researches in Electricity, 3 Vols., 1839, 1844 and 1855.
Fiske, B. A	Electricity in Theory and Practice, 1884.
Fleming, J. A	Short Lectures to Electrical Artisans, 1892.
	Alternate Current Transformers, 2 Vols., 1889 and 1892,
	Electric Lamps and Electric Lighting, 1894.
Fontaine, H	Electrolysis, 1885.
Foote, A. R	Economic Value of Electric Light and Power, 1889.
Gerpil & Kilgour	Pocket-Book of Electrical Engineering Formulæ, 1894.
Gerard, Eric	Electricity and Magnetism, 1897.
Gillett, W	The Phonograph and How to Construct It, 1892.
Gladstone & Tribe	Chemistry of Secondary Batteries, 1883.
Gore, G	Art of Eectro-Metallurgy, 1891.
Gray, Andrew	Magnetism and Electricity, 1898.
	Absolute Measurements, 1889.
Guillemin, A	Electricity and Magnetism, 1891.
Haskins, C. D	Transformers, 1892.
Hawkins & Wallace	The Dynamo, Theory, Design and Manufacture, 1893.
Heap	Paris Electrical Exhibition of 1881, 1884.
Heaviside, Oliver	Electrical Papers, 2 Vols., 1892.
Herrick, A. B	Modern Switchboards, 1898.
Hedges, K	Continental Electric Light Central Stations, 1892.
	American Electric Street Railways, 1894.
Hertz, H	Electric Waves, 1893.
Hering, Carl	Universal Wiring Computor, 1891.
	Electric Railways, 1892.
Hickson	Alternating Currents and Machinery.
	Electro Magnets and the Construction of Dynamos.
Holley, Geo. W	Magnetism, its Potency and Action, 1894.
Hopkins, W. J	The Telephone, 1898.
Hopkins, W. J	Telephone Lines and Their Properties, 1893.
Hughes, N	The Magneto Hand Telephone, 1894.
Hopkinson, Jno	Original Papers on Dynamo Machinery, 1893.
Hospitalier, E	Domestic Electricity for Amateurs, 1885.
	Modern Applications of Electricity, Vol. I, 1883.
	Modern Applications of Electricity, Vol. II, 1887.
Houston, E. J	Electricai Dictionary, 1889.
	Dictionary of Electrical Words, 2 Vols., 1898.
	Electrical Measurements, 1893.
	Electricity One Hundred Years Ago and To-Day, 1894.
	Electric Transmission of Intelligence.
	Electricity and Magnetism, 1897.
Houston & Kennelly	Electric Telegraphy, 1897.
	The Electric Telephone.
	Alternating Electric Currents, 1895.
	Electric Heating, 1895.
	The Electric Motor and Transmission of Power, 1896.
	Electric Incandescent Lighting, 1896.
	Electric Arc Lighting, 1896.
	Magnetism, 1896.
	Recent Types of Dynamo Electric Machinery, 1898.
	Electric Street Railways, 1896.
	Electricity Made Easy, 1898.
Jackson, D. C. and J. P	Alternating Currents, 1896.
Jackson, D. C	Electro Magnetism, 1893.
Jenkin, Fleming	Electricity.

Joyce, Saml................Examples in Electrical Engineering, 1896.
Kapp, Gisbert.............Electric Transmission of Energy.
Alternating Currents of Electricity, 1893.
Transformers for Single and Multiphase Currents, 1896.
Keenan & Riley...........The Transmitted Word, 1893.
Kempe, H. R..............Handbook of Electrical Testing, 1881.
Kilgour, Swan & Biggs....Electrical Distribution.
Kimber, G. H..............Electric Wiring Specifications, 1896.
Langbein & Brannt.......Electro Deposition of Metals, 1894.
Latimer, L. H.............Incandescent Electric Lighting, 1890.
Lintern, Wm..............The Motor Engineers' and Electrical Workers' Handbook, 1897.
Lockwood, T. D...........Practical Information for Telephonists, 1893.
Lodge, O. J................Modern Views of Electricity, 1892.
Lightning Conductors and Lightning Guards, 1892.
Maver, Wm., Jr............American Telegraphy, 1892.
Maver & Davis............The Quadruplex, 1893.
Martin & Wetzler.........The Electric Motor and Its Applications, 1887.
Martin, Thos. C...........Inventions, Researches and Writings of Nikola Tesla, 1894.
Mascart & Joubert........Electricity and Magnetism, 2 Vols., 1883.
Maycock, W. P............Electric Lighting and Power Distribution, 1892.
Maxwell, J. Clerk..........Electricity and Magnetism, 1873.
Elementary Treatise on Electricity, 1881.
Meadowcroft, W. H........The A B C of Electricity, 1888.
Mendenthal, T. C..........A Century of Electricity, 1891.
Merrill, E. A...............Tables and Formulas for Electric Street Railway Engineers, 1894.
Electric Lighting Specifications, 1892.
Niaudet, Alfred............Electric Batteries, 1882.
Nichols, E. T...............A Laboratory Manual of Physics and Electricity, Vol. I, 1894.
A Laboratory Manual of Physics and Electricity, Vol. II, 1894.
Norrie......................Ruhmkorff Induction Coils.
Palaz, A...................Industrial Photometry, 1896.
Paterson, Lummus........Management of Dynamos, 1895.
Parshall & Hobart........Armature Windings, 1895.
Parkhurst, C. D............Dynamo and Motor Building for Amateurs, 1893.
Electric Motor Construction for Amateurs, 1892.
Perry, N. W...............Electric Railway Motors, their Construction, etc., 1896.
Planté.......................Storage of Electric Energy, 1887.
Poole, Jos...................The Practical Telephone Handbook, 1891.
Pope, F. L..................Evolution of Electric Incandescent Lamp, 1889.
The Electric Telegraph, 1891.
Preece and Sivewright....Telegraphy, 1891.
Preece and Maier..........The Telephone, 1889.
Preece and Stubbs........A Manual of Telephony, 1893.
Prescott, Geo. B...........Dynamo Electricity, 1884.
Prindle, H. B..............Electric Railway, 1890.
Ram, G. S...................Incandescent Lamp Manufacture, 1893.
Replogle, M. A.............Electricity and Water Power, 1896.
Robb, R.....................Electric Wiring, 1896.
Russell, S. A..............Electric Light Cables, 1892.
Salamons, D...............Management of Accumulators.
Electric Light Installation, Vol. II, 1894,
Electric Light Installation, Vol. III, 1894.
Schellen, H................Magneto-Electric and Dynamo-Electric Machines, 1884.
Siemens, C. W............Siemens' Scientific Works, 1889.
Slingo *et als*................Cyclopædia of Electrical Engineering, 2 vols., 1891.
Slingo & Brooker..........Problems and Solutions in Electricity, 1895.
Slingo & Brooker..........Electrical Engineering, 1890.
Sloane, T. O'C............Standard Electrical Dictionary, 1892.

Sloane, T. O'C.............How to become a Successful Electrician, 1894.
Arithmetic of Electricity. 1891.
Electric Toy-Making for Amateurs, 1892.
Electricity Simplified, 1891.
Snell, A. T..................Electric Motive Power, 1894.
Spons..... ....Practical Electrics, 4th Edition.
Sprage, Jno. T............Electricity, Its Theory, Sources and Application, 1892.
Steimmetz.................Alternating Current Phenomena.
Still, Alfred................Alternating Currents and Transformers, 1898.
Swinburne, Jas............The Measurement of Electric Currents, 1893.
Symons, G. J..............Report of Lightning-Rod Conference, 1882.
Tesla, Nicola..............Experiments with Alternate Currents, 1892.
Thom and Jones...........Telegraphic Connections and Quadruplex Telegraphy, 1892.
Thompson, S. P...........Dynamo Electric Machinery, 2 vols., 1897.
Electricity in Mining, 1891.
Polyphase Electric Currents. 1895.
Polyphase Electric Currents, 1897.
Electro-Magnet and Electro-Magnetic Mechanism, 1891.
Elementary Electricity and Magnetism, 1881.
Latest Dynamo-Electric Machines, 1897.
Dynamo-Electric Machinery, 1886.
Dynamo-Electric Machinery, 1892.
Polyphase Electric Currents and Alternative Current Motors, 1900.
Thompson, J. J............Recent Researches in Electricity and Magnetism, 1893.
Thompson, E. P...........Röntgen Rays, and Phenomena of Anode and Cathode, 1896.
Treadwell, A..............The Storage Battery, 1898.
Trevert, E. W............Electric Railway Engineering, 1892.
Trowbridge, Jno...........What is Electricity? 1896.
Tungelmann, G. W........Electricity in Modern Life, 1889.
Urquhart, J. W...........Dynamo Construction, 1891.
Electro Motors, 1882.
Electric Ship Lighting, 1892.
Verity, J. B................Electricity Up to Date, 1894.
Von Urbanilsky, A. R.....Electricity in the Service of Man, 1893.
Walker.....................How to Light a Colliery by Electricity.
Walker, S. F..............Electric Lighting for Marine Engineers, 1896.
Electricity in Our Homes and Workshops, 1889.
Webb, H. L................Testing Insulated Wires and Cables, 1895.
Webster, A. G.............Theory of Electricity and Magnetism, 1897.
Wiener ....Dynamo-Electric Machines.
Wilkinson, A. D...........Submarine Cable-Laying and Repairing, 1896.
Whetham, W. C. D........Solutions and Electrolysis, 1895.
Wormell....................Electricity in the Service of Man.
Wright, Lewis.............Induction Coils, 1897.
Philadelphia Electrical Conference, 1884.
American Institute of Electrical Engineers' Transactions, 1884.
Proceedings of Electric Congress, 1893.

MINING, METALLURGY AND GEOLOGY.

Abel, Fred'k A............Mining Accidents, 1889.
Anderson, J. W...........The Prospector's Hand Book, 1888.
Atkinson, J. J.............The Friction of Air in Mines, 1875.
Berthelot & Braun........Explosive Materials, 1883.
Blair, A. A.................The Chemical Analysis of Iron, 1888.
Boyd, R. Nelson...........Coal Pits and Pitmen, 1892.

Charleton, A. G.	Tin, Mining, Dressing and Smelting, 1884.
Cornwall, H. B.	Manual of Blowpipe Analysis, 1888.
Crookes and Rohrig	Kerl's Metallurgy, Vol. I, 1868.
	Kerl's Metallurgy, Vol. II, 1869.
Dana, Edwd. S.	Minerals and How to Study Them. 1895.
Dana, Jas. D.	Manual of Geology, 1879.
	The Geological Story, briefly told, 1875.
Eissler, M	The Metallurgy of Gold, 1888.
Egleston, Thos	The Metallurgy of Silver, Gold and Mercury in the U. S., Vol. I, 1887.
	The Metallurgy of Silver, Gold and Mercury in the U. S., Vol. II, 1890.
Fletcher, E. L.	Quantitative Assaying with the Blowpipe, 1894.
Foye, J. C.	Mineralogy, 1890.
Geikie, A.	Classbook of Geology, 1891.
Gilpin, Edwin	Mines of Nova Scotia, 1880.
Gore, G.	Art of Electro-Metallurgy, 1891.
Greene, Homer	Coal and the Coal Mines, 1890.
Guttmann, O.	Blasting, 1892.
	Manufacture of Explosives, 2 vols., 1895.
Hale, P. M.	Industries of North Carolina, 1883.
Harker, Alfred	Petrology for Students, 1895.
Hildenbrand, W.	Underground Haulage of Coal by Wire Rope, 1884.
Hiorns, A. H.	Mixed Metals or Metallic Alloys, 1890.
Hoffman, H. O.	The Metallurgy of Lead, 1893.
Hopton, Wm.	Conversation on Mines, 1890.
Howe, H. M.	The Metallurgy of Steel, 1891.
Kirkpatrick, T. S. G.	Hydraulic Gold Miners' Manual, 1897.
LeConte, Joseph	Elements of Geology, 1891.
Lesley, J. P.	Geological Survey of Pennsylvania, Vol. III, Part I, 1895.
	Geological Survey of Pennsylvania, Vol. III, Part II, 1895.
Louis, Henry	A Hand Book of Gold Milling, 1894.
Lupton, Arnold	Mining, 1893.
Meade, Rich'd.	The Coal and Iron Industries of the United Kingdom, 1882.
Merrill, Geo. P.	Rocks, Rock Weathering and Soils, 1897.
Moses & Parsons	Elements of Mineralogy and Crystallography, 1895.
Nicolls, Wm. J.	Story of American Coals, 1897.
	Coal Catechism, 1898.
Patton, J. H.	Natural Resources of the United States, 1894.
Park, Jas.	Cyanide Process of Gold Extraction, 1900.
Percy, John	Metallurgy, 1875.
	Metallurgy, Part I, 1880.
	The Metallurgy of Lead, 1870.
Peters, Edw'd D.	Modern Copper Smelting, 1887.
Phillips, J. A.	Ore Deposits, 1884.
	Elements of Metallurgy, 1887.
Phillips, J. S.	The Explorers and Assayers' Companion, 1881.
Poole	Mining Directory, etc., U. S., Canada and Mexico, 1898.
Porter, Rob't P.	Report on Mineral Industries in U. S., 1890.
Pulsifer, W. H.	Notes for a History of Lead, 1888.
Roberts-Austen, W. C.	An Introduction to the Study of Metallurgy, 1891.
Rose, T. K.	The Metallurgy of Gold, 1894.
Rothwell, R. P.	The Mineral Industry, Vol. I. 1892.
	The Mineral Industry, Vol. II, 1893.
	The Mineral Industry, Vol. III, 1894.
	The Mineral Industry, Vol. IV, 1895.
	The Mineral Industry to the End of 1896, Vol. V, 1897.
	The Mineral Industry to the End of 1897, Vol. VI, 1898.
	The Mineral Industry to the End of 1898, Vol. VII, 1899.

Rothwell, R. P............The Mineral Industry for 1899, Vol. VIII, 1900.
Sanford, P. G.............Nitro Explosives, 1896.
Saward, F. E.............The Coal Trade, 1892.
The Coal Trade, 1893.
Statefeldt, C. A..........The Lixiviation of Silver Ores, 1888.
Russell's Improved Process for the Lixiviation of Silver Ores.
Tarr, R. S................Economic Geology of the U. S., 1894.
Thompson, Sir Wm.......Popular Lectures and Addresses, 1894.
West, Thos. D............Metallurgy of Cast Iron, 1897.
Wilson, E. B..............Cyanide Processes, 1896.
Hydraulic and Placer Mining, 1898.
Winchell, Alex...........Geological Excursions, 1889.
Geological Studies, 1889.
Wisser, Jno. P............Modern Gun Cotton, 1886.
Explosive Materials, 1898.
Wright, G. F.............The Ice Age in North America, 1889.
The Iron and Steel Institute of America, 1890.
The Mine and Quarry News Bureau, 1897.
The Mine, Quarry and Metallurgical Record.
School of Mines Quarterly, May, 1882.

CHEMISTRY AND PHYSICS.

Abney, Capt. W. de W....Color Vision, 1895.
Arnott, Neil...............Elements of Physics, 1880.
Austen, P. T...............Notes for Chemical Students, 1896.
Bamber, E. F.............Siemens Scientific Works, 1889.
Ball, W. W. Rouse........An Essay on Newton's Principia, 1893.
Barbury, S. H.............Kinetic Theory on Gases, 1899.
Barker, Geo. F...........Physics, 1892.
Bayley, Thos.............Chemists' Pocket Book, 1900.
Bowney, T. G.............The Year Book of Science, 1893.
Classen, Alex.............Quantitative Chemical Analysis by Electrolysis, 1888.
Dallmeyer, Thos. R.......Telephotography, 1899.
Everett, J. D.............Deschanel's Natural Philosophy, 1891.
C. G. S. System of Units, 1881.
Frankland, Percy and Mrs.Micro-Organisms in Water, 1894.
Ganot.......................Elementary Treatise on Physics, 1883.
Helm, Geo................The Principles of Mathematical Chemistry, 1897.
Hopkins, Wm. J...........Preparatory Physics, 1894.
Hopkins, Geo. M..........Experimental Science, 1893.
Ingle, Herbert.............Chemistry of Fire and Fire Prevention, 1900.
Kimball, A. L.............Gases, Physical Properties of, 1890.
Landauer, Jno............Spectrum Analysis, 1898.
Leet, A. L.................Petroleum Distillation, 1884.
Lietze, Ernst.............Modern Heliographic Processes, 1888.
Loudon and McLennan...Experimental Physics, 1895.
Lunge, Geo................A Treatise on the Distillation of Coal Tar and Ammonia Liquor, 1882.
Coal Tar and Ammonia, 1887.
Meldola, Raphael.........The Chemistry of Photography, 1889.
Mill, H. R..................The Realm of Nature, 1892.
Molloy, G...................Gleanings in Science, 1888.
Morgan, J. L. R...........Theory of Solution and its Results, 1897.
Newman, Geo.............Bacteria, 1899.
Pattison, Muir.............Principles of Chemistry, 1889.
Permain and Moor.........Applied Bacteriology.
Ostwald, W...............Analytical Chemistry, 1895.
Risteen, A. D..............Molecules and Molecular Theory, 1895.

Schenck, S. L.	Elements of Bacteriology, 1893.
Siemens, C. W.	Siemens Scientific Works, 1889.
Sloane, T. O'Conor	Liquid Air and Liquefaction of Gases, 1899.
Spencer, G. L.	A Hand Book for Chemists of Beet Sugar Houses, 1897.
Stewart & Gee	Elementary Practical Physics, Vol. I, 1885.
	Elementary Practical Physics, Vol. II, 1887.
Stillman, F. B.	Engineering Chemistry, 1897.
Tait, P. G.	Properties of Matter, 1885.
Tilden, Wm. A.	Progress of Scientific Chemistry, 1899.
Tillman, S. E.	Descriptive General Ceemistry, 1899.
Tyndall, Jno.	Light and Electricity, 1871.
	On Sound, 1891.
	On Light, 1889.
Vulte & Neustadt	Laboratory Manual of Inorganic Preparations, 1895.
Wagner, R.	A Hand Book of Chemical Technology, 1872.
Wagner, R. von	Handbuch der Chemischen Technologie, 2 vols., 1886.
Whetham, W. C. D.	Solution of Electrolysis, 1895.
Wiley, H. W.	Agricultural Analysis (Soils), 1894.
	Agricultural Chemical Analysis, Vol. III, 1897.
	Agricultural Analysis (Fertilizers), 1895.
Wood, De Volsom	The Luminiferous Ether, 1886.

LANDSCAPE GARDENING AND TIMBER PHYSICS.

Atlett, W. H.	English Trees and Tree Planting, 1880.
Apgar, A. C.	Trees of Northern United States.
Britton, T. A.	A Treatise on Dry Rot in Timber, 1875.
Brisbin, J. S.	Trees and Tree Planting, 1888.
Browne, D. J.	The Trees of America, 1857.
Egleston, N. H.	Hand Book of Tree Planting, 1884.
Elliott, F. R.	Lawn and Shade Trees, 1868.
Emerson, G. B.	Trees and Shrubs of Massachusetts, 1846.
Furst, H.	The Protection of Woodlands, 1893.
Hartig, R.	Text Book on Diseases of Trees, 1894.
Houston, E. J.	Outlines of Forestry, 1893.
Jonssen-Rose	Lawns and Gardens, 1897.
Kemp, Edwd.	Landscape Gardening, 3d ed., 1894.
King, F. H.	The Soil, 1895.
Laslett, Thos.	Timber and Timber Trees.
Lubbock, Jno.	Seedlings, Vol. I, 1892.
	Seedlings, Vol. II, 1892.
Maynard, Saml. T.	Landscape Gardening, Home Decoration, 1899.
Newhall, C. S.	The Leaf Collector's Hand Book, 1891.
Parsons, Saml., Jr.	Landscape Gardening, 1891.
Parsons, Saml., Jr.	How to Plan the Home Grounds, 1899.
Sexby, J. J.	Municipal Parks, Gardens, etc., London, 1898.
Stevenson, W.	The Trees of Commerce.
Stewart, Henry	Irrigating for Farm, Garden and Orchard, 1886.
Tricker, Wm.	The Water Garden, 1897.
Ward, H. M.	The Oak.
	Timber and some of Its Diseases, 1889.
Waugh, F. A.	Landscape Gardening, 1899.
N. Y. Forest Commission.	Special Report on Adirondack State Park, 1891.
	Department of Agriculture, Year Book, 1895.

SURVEYING, MATHEMATICS AND MAPPING.

Baker, Ira O.	Leveling: Barometric, Trigonometric, etc., 1887.
	Engineers' Surveying Instruments, 1900.
Ball, W. W. Rouse	Mathematical Recreations and Problems, 1896.

Barnard, F. A. P.	The Metric System, 1872.
Byerly, Wm. E.	Elements of Integral Calculus, 1890.
Carll, L. B.	Treatise on the Calculus of Variations, 1881.
Clarke, A. R.	Comparisons of Standards of Length, 1866.
Davies, Chas.	The Metric System, 1871.
Duffield, W. W.	Logarithmic Tables, 1897.
Gore, J. H.	Geodesy, 1891.
Gould, E. Sherman	A Primer of the Calculus, 1896.
Jackson, Geo.	The Metric System, 1889.
Jacoby, H. S.	Plain Lettering.
Jessop, C. M.	Elements of Applied Mathematics, 1894.
Johnson, W. W.	Theory of Errors and Method of Least Squares, 1896.
Merriman, M.	Goedetic Surveying, 1893.
	Precise Surveying and Geodesy, 1899.
Merriman & Woodward	Higher Mathematics, 1896.
Middleton, G. A. T.	Surveying and Surveying Instruments, 1894.
Newcomb, S.	The Essentials of Trigonometry, 1884.
Putnam, J. P.	The Metric System, 1874.
Reinhardt	Lettering, 1895.
Robinson, J. L.	A Treatise on Marine Surveying, 1882.
Runkle, J. D.	Elements of Plane Analytic Geometry, 1888.
Smith, Chas.	Geometrical Conics, 1894.
Specht, Geo. C. *et al.*	Topographical Surveying, 1884.
Townsend, Rev. Rich.	Chapters on Modern Geometry, 1863.
Whymper, Edwd.	Aneroid Barometer, 1891.
Williamson, R. S.	The Barometers in Surveys and Reconnoissances, 1868.
Wilson, Herbert M.	Topographic Surveying, 1900.
Winslow, Arthur	Stadia Surveying, 1892.
Wurtele, A. S. C.	Standard measures of the United States, 1882.
Zirvet, Alex.	Treatise on Theoretical Mechanics, 1894.
	Report of Coinage Weights and Measures Committee, 1879.

ASTRONOMY AND NAVIGATION.

Ball, R. S.	The Story of the Heavens, 1891.
Bowditch, N.	The New American Practical Navigator, 1861.
Brainard, F. R.	The Sextant, 1891.
Chambers, Geo. F.	Astronomy, Vol. I, 1889.
	Astronomy, Vol. II, 1890.
	Astronomy, Vol. III, 1890.
Chauvenet, Wm.	Spherical and Practical Astronomy, 1864.
	Spherical and Practical Astronomy, Vol. II, 1868.
Clark, Lewis	Theoretical Navigation, 1872.
Davis, J. W.	Dynamics of the Sun, 1891.
English, V. J.	Navigation for Yachtsmen, 1896.
Flight, W.	The History of Meteorites, 1887.
Frost, E. B.	Astronomical Spectroscopy, 1894.
Greene, Dascom	Spherical and Practical Astronomy, 1891.
Henderson, W. J.	The Elements of Navigation.
Lecky, S. T. S.	General Utility A B C and D Tables, 1897.
Lee, T. J.	Astronomical Tables and Formulæ, 1893.
Lockyer, J. N.	The Meteoritic Hypothesis, 1890.
Luce, Com. S. B.	Text Book of Steamship, 1898.
Mitchel, O. M.	Popular Astronomy, 1860.
Nasmyth & Carpenter	The Moon, 1885.
Oliver, J. A. W.	Astronomy for Amateurs, 1888.
Proctor, R. A.	The Universe of Suns, 1884.
	The Expanse of Heaven, 1889.

Roberts, F. C............. The Figure of the Earth, 1885.
Serviss, G. P...............Astronomy with an Opera Glass, 1890.
Thompson, Sir Wm.......Popular Lectures and Addresses, 1891.
Tyndall, Jno...............New Fragments, 1892.
Young, C. A....,........The Sun, 1890.

METEOROLOGY.

Davis, Wm. M.............Whirlwinds, Cyclones and Tornadoes, 1884.
Elementary Meteorology, 1894.
Draper, Daniel............New York Meteorological Records, 1878, 1895 to 1900 inclusive.
Espy, Jas. P...............Meteorological Report to the United States Government, 1854.
Ferrell, Wm..............Winds, 1889.
Finley, J. P...............Tornadoes, 1887.
Greely.....................American Weather, 1888.
Hazen, H. A...............The Tornado, 1890.
Huxley, T. H..............Physiography, 1878.
Jackson, L. D. A..........Modern Meteorology, 1882.
Parnell, Arthur...........Action of Lightning, 1882.
Perley, Sidney............Historic Storms of New England, 1891.
Prince, J. J................Physiography, 1883.
Russell, Thos..............Meteorology, 1895.
Spader, P. V...............Weather Record, New Brunswick, N. J., 1847-1890.
Spang, H. W...............Lightning Protection, 1877.
U. S. Weather Bureau....Reports of Chief, 1891-1896.
Reports International Meteorological Congress, Chicago, 1893
Waldo, Frank.............Modern Meteorology, 1893.
Williamson, R. S..........Use of the Barometer, 1868.

INDEXES.

American Institute Mining Engineers...........Index to Transactions, 3 vols., 1871 to 1895.
Association of Engineering Societies.............Index of Current Engineering Literature, 1884-1891.
Franklin Institute Journal.......................Index, 2 vols., 1826 to 1895.
Galloupe, F. E............An Index to Engineering Periodicals, 1883-1887.
Haferkorn, H. E..........Handy Lists of Technical Literature, 2 vols., 1880 to 1888.
Johnson, J. B..............Engineering Index, 1892-1895.
Society of Engineers......Index to Transactions, 1857-1898.
The Engineering News....General Index—Engineering News, 1874-1890.
Electrical World..........Index to Electrical World, 1883 to 1896.

BOUND VOLUMES OF SOCIETY TRANSACTIONS.

American Association for Advancement of Science, Vols. 20-47, inclusive.
American Institute of Electrical Engineers, Vols. 12 to 15.
American Institute of Mining Engineers, Vols. 1-29, 1871-1899.
American Public Health Association Journal, Vols. 4, 7, and 15-24, inclusive, except Vols. 22 and 23.
American Society of Civil Engineers, Transactions, 1895-1899.
American Society of Mechanical Engineers, Transactions, Vols. 14-20, 1893-1899.
Annales des Ponts et Chaussées, 1895-1899, inclusive.
Association of Engineering Societies, Journal of, Vols. 15-24.
Brooklyn Engineers' Club, Proceedings, 1897-1899.
Franklin Institute, Journal of, 1828-1851, and 1873-1899, inclusive.

Institution of Civil Engineers, Proceedings, Vols, 75–139, inclusive, 1884–1899.
Iron and Steel Institute, Journal of, Vols. 51–57, 1897–1900.
Master Car-Builders' Association, Proceedings, Vol. 30, 1896.
Municipal and County Engineers, Proceedings, Vols. 22–25, 1895–1899.
Naval Architects and Marine Engineers, Transactions, Vols. 1–7, inclusive, 1893-1899.
New England Water-Works Association, Journal, Vols. 10–13.
Philadelphia Engineers' Club, Proceedings, Vols. 5, 12–13, 15.
Society of Engineers, Transactions, 1894–1899, inclusive.
Société des Ingénieurs, Civils, Mémoires de la, 1895-1899.
Western Society of Engineers, Journal, Vols. 1–3, inclusive.

BOUND VOLUMES OF PERIODICALS, Etc.

American Architect and Building News, Vols. 11–68, except Vol. 20, 1882–1899.
American Journal of Science, Vol. 6–22, inclusive, except Vols. 7 and 16.
Builder, The, Vols. 18-78, inclusive, 1860–1900.
Building News, Vols. 16–78, inclusive, 1869–1900.
Cassier's Magazine, Vols. 8–17, inclusive, 1895–1899.
Chemical News, Vols. 21–80, inclusive, 1870–1899.
Digest of Physical Tests, Vols. 1–3, 1896–1898.
Electrical Engineer, Vols. 3-26, inclusive, 1888–1898.
Electrical World, Vols. 25–34, inclusive, 1895–1899.
Electrician, The, Vols. 39–45, 1897–1900.
Engineer, The, Vols. 27–88, inclusive, 1869-1899.
Engineering, Vols. 7–66, inclusive, 1869–1899.
Engineering Magazine, Vols. 1–17, inclusive. Vol. 19, 1891–1899.
Engineering and Mining Journal, 1872–1899, inclusive, except 1874–75 and 1892.
Engineering News, 1878–1899, inclusive, except 1883.
Engineering Record, Vols. 31–40, inclusive, 1895–1899.
Good Roads, Vols. 2 and 3, 1892 and 1893.
Microscopical Science, Quarterly Journal, Vols. 20-42, except Vol. 32, 1880–1899.
Municipal Engineering, Vols. 4–18, 1893–1900.
New York Meteorological Observations, 1878, 1895–1900, inclusive.
Physical Tests, Digest of. Vols. 1–3, 1896–1898.
Ponts et Chaussées, Annales des, 1895-1899.
Popular Astronomy, Vols. 1–7, inclusive, 1893–1899.
Railroad Gazette, Vols. 29–31, 1897–1899.
Sanitary Record, Vols. 21–24, inclusive, 1898 and 1899.
Science, 1884–1900, inclusive, except 1894.
School of Mines Quarterly, Vols. 3, and 11–18, inclusive.
Street Railway Journal, Vols. 11, 13 and 15, 1895–1897–1899.
U. S. Army, Chief of Engineer's Report, 1891–1899, inclusive
Van Nostrand's Eclectic Magazine, Vols. 1–36, inclusive.

FILES OF PERIODICALS REGULARLY RECEIVED.

Aluminum World.
American Association for Advancement of Science.
American Architect and Building News.
American Institute of Electrical Engineers.
American Institute of Mining Engineers.
American Microscopical Journal.
American Public Health Association Journal.
American Journal of Science.
American Society of Civil Engineers, Transactions of.
American Society of Mechanical Engineers.
American Society of Municipal Improvements.
American Water-Works Association.

Annales des Ponts et Chaussées.
Association of Engineering Societies, Journal of.
Brooklyn Engineers' Club, Proceedings of.
Builder, The.
Building News.
Cassier's Magazine.
Chemical News.
Electrical World and Engineer.
Electrician, The.
Engineer, The.
Engineering Magazine.
Engineering and Mining Journal.
Engineering News.
Engineering Record.
Engineering.
Franklin Institute, Journal of.
Geological Magazine.
Incorporated Association of Municipal and County Engineers.
Iowa Engineering Society, Proceedings of.
Institution of Civil Engineers, Proceedings of.
Iron and Steel Institute, Journal of.
Manufacturers' Record.
Master Car Builders' Association. Proceedings of.
Microscopical Science, Quarterly Journal of.
Mining and Metallurgy.
Municipal Engineering.
Municipal and County Engineers, Incorp. Assoc. of, Proceedings.
Naval Architects and Marine Engineers, Transactions of,
New England Water-Works Association, Journal of.
New York Meteorological Observations.
New York State Board of Health, Bulletin of.
Ohio Sanitary Bulletin.
Ohio Society of Surveyors and Civil Engineers.
Philadelphia Engineers' Club, Proceedings of.
Ponts et Chaussées, Annales des.
Popular Astronomy.
Progressive Age.
Public Improvements.
Railroad Gazette.
Sanitary Record.
Science.
Scientific American Supplement.
Scientific Literature, Monthly Record of.
Society of Engineers, Transactions of.
Société des Ingénieurs Civils, Mémoires de la.
School of Mines Quarterly.
Stevens Indicator.
Stone.
St. Louis Engineers' Club, Proceedings of.
Street Railway Journal.
United States Army, Report of Chief of Engineers.
United States Weather Bureau, Report of Chief of.
Water and Gas.
Western Society of Engineers, Journal of.

ALPHABETICAL LIST OF ADVERTISERS.

This Book was Printed

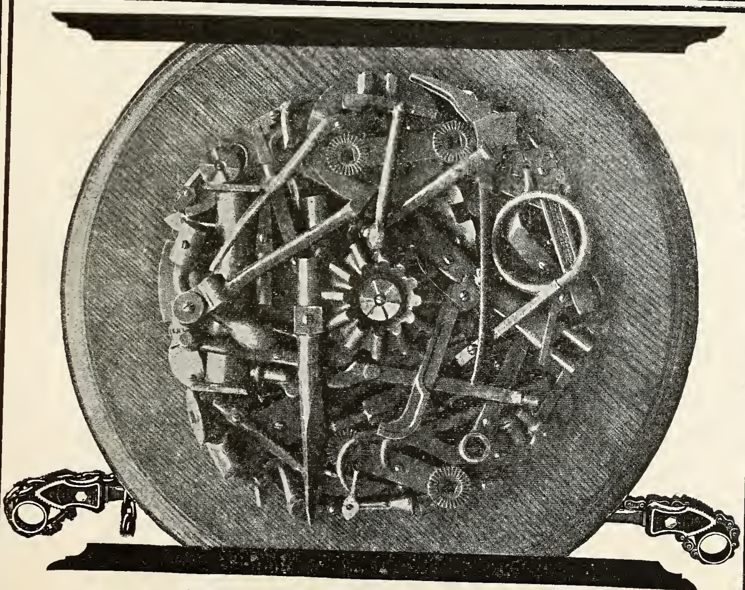
by

The Evening Post

Job Printing House,

156 Fulton Street,

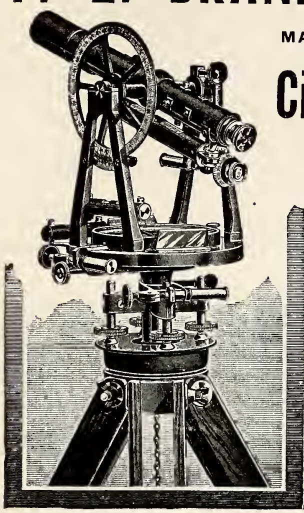
New York.



BRONZE FOUNTAIN FOR U. S. SAFE DEPOSIT CO., BOSTON, MASS.
C. H. BLACKALL, Architect.

ESTABLISHED 1872.

F. E. BRANDIS SONS & CO.,



MANUFACTURERS OF

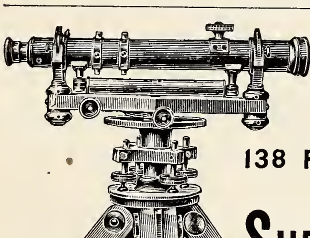
Civil Engineers' and Surveyors'

INSTRUMENTS

812-814 Gates Avenue,

BROOKLYN, N. Y.

Catalogues sent on application by mentioning Brooklyn Engineers' Club.



KOLESCH & CO.,

SUCCESSORS TO

F. ECKEL, formerly BLUNT & CO.,

138 Fulton Street, NEW YORK,

MANUFACTURERS OF

SURVEYING INSTRUMENTS,

Special Facilities for Repairing.

Catalogue of Architects and Engineers' Supplies on Application.

C. L. Berger & Sons,

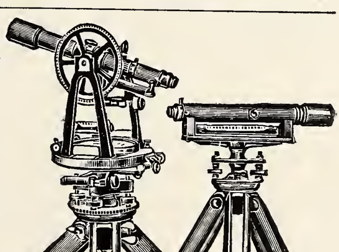
SUCCESSORS TO BUFF & BERGER,

Manufacture all kinds of

Surveying, Engineering and Astronomical Instruments.

Large Illustrated Catalogue and Manual of their Improved Engineers' Field Instruments, Tapes, Chains, Leveling-rods, etc.

Instruments Carefully Repaired and Adjusted.



No. 9 PROVINCE COURT,

BOSTON, MASS.

THE Publication Committee desires to call the special attention of the Club to the advertisers. Let us help those who help us, and thus cause this book to be recognized as the valuable advertising medium it is.